SCIENCE

APRIL 3, 1953

VOLUME 117 NUMBER 3040

Contents

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

SQUEEZE TYPE

Polyethylene WASH BOTTLES

- *UNBREAKABLE*
- *LIGHTWEIGHT*
- *FLEXIBLE*
- *CHEMICALLY RESISTANT*
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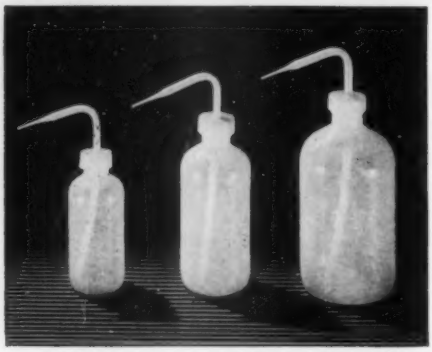

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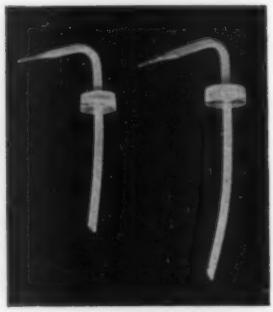

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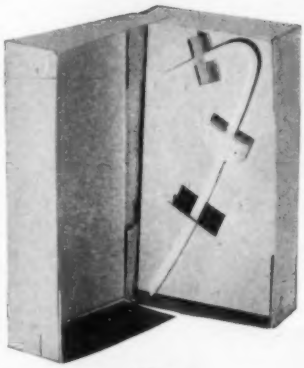

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Punched-Card Bibliography of Infrared Spectra

ONE of the newer developments in the field of chemistry is the widespread application of the techniques of infrared spectroscopy to chemical problems. Not only are the infrared spectra of chemical compounds useful analytical tools, but they also provide important information on the molecular forces that determine chemical properties.

With the rapid growth of information on the infrared absorption of chemical compounds, workers in the field have been faced with the problem of quickly gaining access to the results obtained by others. About 500 papers a year are now being added to the already large supply of available literature on the subject. In general, this literature is widely scattered, because papers dealing with instrumental advances, calculation of structure, techniques of sample handling, and analytical procedures appear in separate journals. Yet, because of its incidental application as a special technique in many fields, the presence of infrared in a publication often fails to be indicated in any index.

Moreover, each laboratory that uses infrared techniques requires a large library of infrared spectra as an aid in qualitative identification and empirical determination of structure. This has caused a vast duplication of effort, particularly in the collection and purification of the chemical compounds involved. And, once the data have been obtained, the charts produced by automatic recording spectrometers are so large as to require special indexing and storage facilities.

To meet these problems, a comprehensive punched-card catalogue of all available data on the infrared spectra of organic and inorganic compounds is being set up by the National Bureau of Standards under the sponsorship of the National Research Council's Committee on Spectral Absorption Data. The card catalogue not only fills the pressing need for a general reference library of infrared spectra but also provides a survey of the literature on each compound, abstracts of the papers covered, and other useful data. By means of the punched cards, the reported spectra of many compounds can be quickly found, the more important chemical linkages associated with a given spectral line can be determined, the work of any given author can be quickly assembled, and the properties of a compound that will aid in its identification can be located without loss of time.

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A bibliography of between 9000 and 10,000 infrared references has been contributed by the National Bureau of Standards and is being kept current with the aid of a group of volunteer abstracters. A search of approximately half these references has yielded a file of about 7500 compounds. As infrared spectra are contributed by cooperating laboratories, the applicable literature references accumulated to date are tabulated on the cards, which are then printed, slotted, and sold at cost. (Detailed instructions for ordering may be obtained from the National Bureau of Standards, Washington 25, D. C.) Efforts are now being made to extend the present coverage to the visible and ultraviolet regions, as well as to the infrared.

E. CARROLL CREITZ

NRC Committee on Spectral Absorption Data
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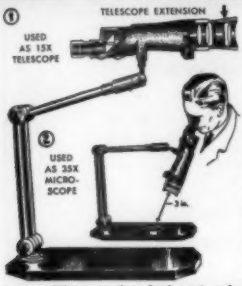

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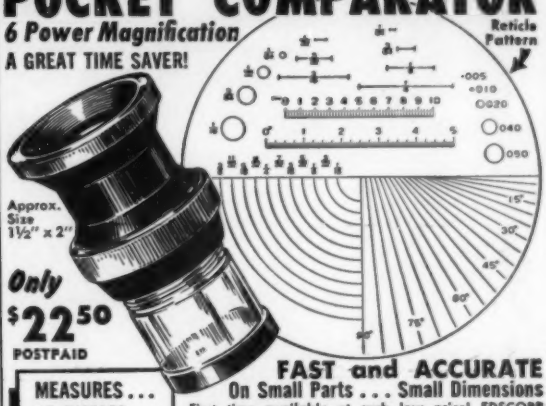

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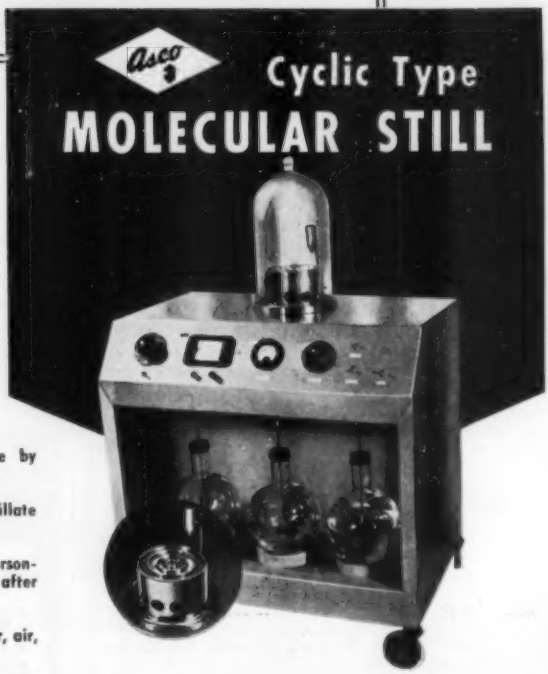

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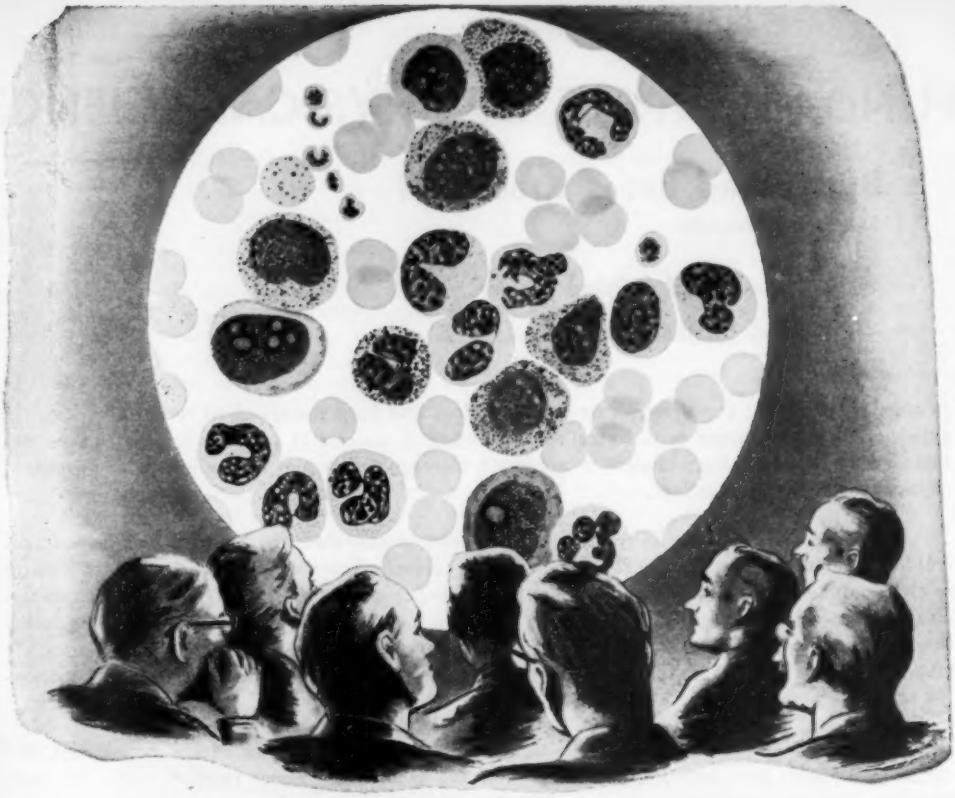

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Thermoluminescence as a Research Tool

Farrington Daniels, Charles A. Boyd, and Donald F. Saunders[1]

Department of Chemistry, University of Wisconsin, Madison

THERMOLUMINESCENCE IS THE EMISSION OF LIGHT produced by heating a solid to a temperature below that of incandescence. It is exhibited by crystals, such as alkali halides, that have been exposed to x-rays or radioactivity and then heated rapidly. The high-energy radiation dislodges electrons, some of which become trapped in lattice imperfections, and are later driven out with the accompanying emission of light when the temperature is raised to supply the necessary amount of kinetic energy.

Thermoluminescence is a property that is extremely sensitive to changes in the structure of crystals. Changes in minor impurity concentrations, crystallization techniques, and physical treatments all produce profound effects. This structure sensitivity is found in other solid state properties such as catalytic activity, dielectric constant, magnetic susceptibility, light absorption, fluorescence, and phosphorescence. Because of the similarities between thermoluminescence and these other properties it is thought that thermoluminescence measurements may be of value in their interpretation.

The application of thermoluminescence in the analysis of minerals and control of feldspars in the ceramics industry has been described by Deribere (*1, 2*). It has been used in the interpretation of phosphorescence mechanisms by Garlick and others (*3*). Further interesting uses of this phenomenon were suggested in preliminary reports (*4–6*), and it is the purpose of the present communication to outline progress in the application of thermoluminescence to a variety of research problems.

Apparatus

The technique of measuring thermoluminescence by the so-called glow curves, developed initially by Urbach (*7*) and modified by Randall (*8*) and Boyd (*9*), has been simplified so that many thermoluminescent substances can be studied rapidly and conveniently.

The intensity of light as measured with a multiplier phototube, and the temperature as determined by a thermocouple, are recorded simultaneously, using a recording potentiometer. The specimen is heated at a uniform rate of 1° C per second, producing records such as that shown in Fig. 1. The straight line is a record of the temperature, and the light intensity passes through a series of maxima. The crystalline material is prepared either as a powder or as a plate about 1 cm square and 1.5 mm thick, obtained by cleaving crystals or cutting rocks with a diamond saw. The powder usually gives a lower light intensity on account of the scattering of the light within the sample, but it is more reproducible because it averages out the heterogeneity of the specimen. It is ground to 100–200 mesh size, and a weighed quantity of about 20 mg is placed on a thin glass plate and moistened with a drop of water containing a trace of detergent. After drying, the powder sticks to the glass well enough to be handled. The electrically heated silver hot plate is adjusted by means of a variac to give a uniform temperature rise as recorded on the graph, more current being allowed to pass as the furnace heats up and the heat losses become greater. The apparatus is enclosed in a light-tight box and, after heating the sample to dull red heat, where thermoluminescence can no longer be detected, the hot plate is removed and cooled quickly with dry ice for the next determination.

Most of the irradiation of crystals has been carried out in two special γ-ray irradiators, each consisting of two concentric aluminum tubes, with cobalt powder filling the annular space between them (*10*). We are indebted to the Argonne National Laboratory and the Oak Ridge National Laboratory for placing these irradiators in nuclear reactors to produce radioactive cobalt (Co^{60}). In this way a space 2.2 cm in diameter by 8 cm long is available for uniform irradiation with 1.1 and 1.3 mev γ-rays at intensities of 6000 or 1400 roentgens per hour for 4 or 1.3 curies of Co^{60}, respectively.

Mechanisms

To exhibit thermoluminescence, a substance must have an ordered structure such as is found in crystals, or a semiordered structure as in glasses. In addition, it must be electrically an insulator or semiconductor. The crystal must be exposed to ionizing radiation that will produce a cloud of electrons within the lattice when the radiation is absorbed.

The ability to exhibit thermoluminescence in certain crystals can be produced by a variety of high-energy radiations—hard or soft x-rays, γ-rays, α-particles, and β-rays. An energy of about 10 ev is sufficient to remove electrons from ions in most crystal lattices and to provide them with energy to move around in the crystal, but unless there are traps into which the released electrons can go, there is no mechanism to provide for thermoluminescence. There are several different kinds of possible electron traps: (*a*) imperfections and vacancies in the crystal lattice produced at the time the crystal is formed, or created later by

[1] The authors are pleased to acknowledge the support of this project by grants from the Atomic Energy Commission.

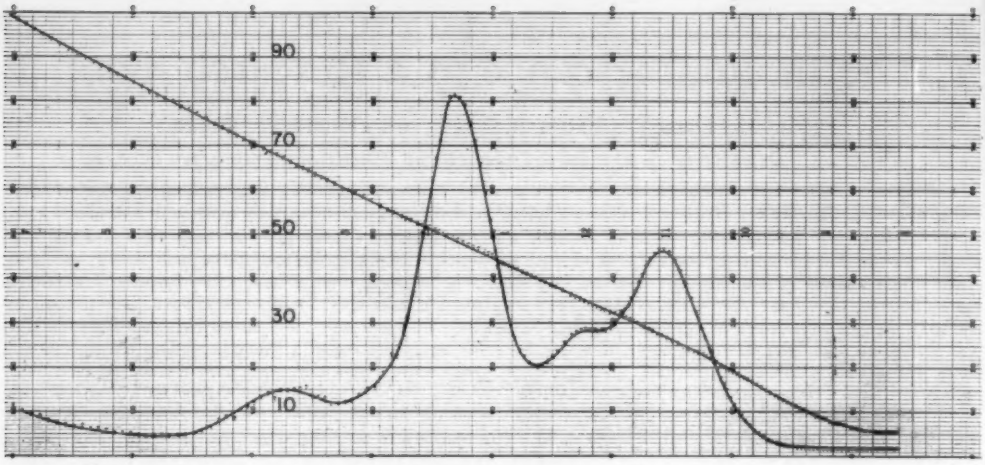

FIG. 1. Typical glow curve recording; γ-activated thermoluminescence of a limestone. 0 = 0°C; 100 = 500°C; 0 = 0 microamp; 100 = 1 microamp. Heating rate = 0.8°C/sec. 115 hr-exposure in γ-source.

mechanical pressure or thermal treatment; (*b*) statistical imperfections that are due to kinetic motions and that increase in number at higher temperatures; (*c*) distortions produced by impurity ions of larger or smaller size than those comprising the crystal lattice; and (*d*) ion dislocations, or "holes," produced by radioactive bombardment.

One of the common types of traps is a negative ion vacancy—for example, a chloride ion missing from a sodium chloride lattice. When such a vacancy is filled with a dislodged electron, it is called an F-center, and it acts as a light-absorbing unit. The color produced by x-radiation in crystals and that found in some fluorites and other minerals containing radioactive impurities are thought to be due to the creation of these F-center and other arrangements of trapped electrons (*11, 12*). It has long been known that this coloration can be bleached out by heating (*13*); it is not quite so well known that thermoluminescence usually accompanies the removal of the color.

A crystal may possess many trapped electrons within its lattice and may not produce thermoluminescence when heated unless there is some mechanism for releasing the extra energy of the electrons as visible light. This mechanism is thought to take place in certain emission centers in the lattice, associated with impurities, as is the case in many artificial phosphors and natural fluorites (*14–16*), or perhaps with displaced lattice ions or other irregularities in the lattice.

The role of impurities in determining the character of thermoluminescence has been discussed by Alt and Steinmetz (*17*). Our investigation has shown that individual peaks in fluorite glow curves emit different colors of light. This would seem to indicate that these electron traps are intimately associated with particular emission centers, which have been demonstrated to be rare earth impurities (*16*). In this case it is thought that the electrons are trapped in distortions produced by the foreign ions.

The production of ion dislocations in various materials by α-particles has been studied by Seitz (*18*) and Slater (*19*). Halos of color around radioactive inclusions in minerals are thought to be due to electrons trapped in dislocations produced by α-particles. Certain feldspars exhibit very intense thermoluminescence from such halos, and it is concluded that the electron traps responsible were produced by the α-bombardment. Estermann (*20*) detected changes in density in KCl crystals exposed to x-rays. These were ascribed to the production of vacancies in the lattice by the radiation. Lithium fluoride has been found to produce increased thermoluminescence on each successive equal exposure to γ-rays from Co^{60}. The increased sensitivity is thought to be the result of the production of additional electron traps by γ-radiation.

Each peak in a glow curve corresponds to a definite energy level of trapped electrons, and low-temperature peaks can be drained out without affecting the high-temperature peaks if the heating is stopped before the high temperatures are reached. The amount of thermoluminescence of a given peak is a result of a balance between the rate at which electrons have been driven into the traps by radiation and their rate of thermal escape at the temperature of irradiation. When the temperature of the irradiated crystal is raised quickly and then maintained constant, the intensity of luminescence decays, with a definite mathematical relation from which the energies of activation (*9*) of a specified type of trapped electron can be calculated.

The thermoluminescence behavior on continued irradiation has been studied in considerable detail and will be reported elsewhere. In general, saturation oc-

curs at an energy input that varies with the crystal and the type of radiation. Low-temperature peaks are apt to become less prominent with continued irradiation, and new high-temperature peaks are created. The alkali halides and limestones are apt to reach saturation after about 100,000 roentgens of Co^{60} γ-radiation. Continued irradiation may simply give a constant thermoluminescence intensity or it may give a decreasing intensity.

Types of Thermoluminescent Materials

The alkali halides are all thermoluminescent. In general they have two prominent peaks which shift with the size of the ions, the smaller atoms giving thermoluminescence which comes in at higher temperatures and coloration from F-centers with absorption maxima at shorter wavelengths (*21*). In lithium fluoride, where both ions are small, the coloration produced by radiation comes in the ultraviolet, and the maxima in the thermoluminescence curves occur at about 220° C and at 320° C.

In addition to the alkali halides, the following give thermoluminescence after irradiation with γ-radiation —calcite, dolomite, fluorite, aluminum oxide, magnesium oxide, gypsum, quartz, glass, certain catalysts, feldspars, feldspathoids, certain dried clays, and ceramics. A large variety of inorganic crystals is being investigated for thermoluminescence, and more sensitive apparatus for testing thermoluminescence is being developed. In general, hard, transparent or translucent crystals of simple crystal structure are most apt to exhibit thermoluminescence after exposure to γ-rays.

Sometimes, of course, the thermoluminescent light emitted probably escapes detection with the present apparatus because it is in the ultraviolet or the infrared. Organic material cannot be studied in air because combustion emits obscuring light, but there is reason to believe that, if certain organic substances are irradiated at liquid air temperatures and then heated to room temperature and above, they, too, will exhibit thermoluminescence. Prominent additional, low-temperature peaks were found in the glow curves when the alkali halides were irradiated at liquid air temperatures (*21*). These peaks are, of course, registered as fluorescence when irradiated at room temperature, the light being emitted at the time of irradiation.

The presence of impurities is an important factor in thermoluminescence glow curves, and, until theories can be developed to account for the different activation energies of the various energy traps, it is difficult to know whether a given peak is characteristic of a given crystal lattice or of a given impurity, perhaps present in traces.

Preliminary work has been done on the effect of added impurities and mixtures of salts crystallized out together from a given melt (*22*). When 1 mole per cent of silver chloride is added to fused sodium chloride, for example, the crystallized salt gives 100 times as much intensity of thermoluminescence as the pure sodium chloride alone. Traces of cupric chloride and manganese chloride, on the other hand, quench the thermoluminescence. When potassium bromide is added to sodium chloride and the two are fused and crystallized, a curve of thermoluminescence intensity plotted against mole fraction gives a maximum at which the intensity of the mixed crystals is considerably greater than that of either sodium chloride or potassium bromide alone. The distortion of the lattice by the introduction of ions of different sizes seems to create holes in which electrons, released by γ-rays, can be trapped.

The color of the thermoluminescence varies at least over the whole visible spectrum with different crystals, and it is quite sensitive to impurities.

Dosimetry

Since in many crystals the intensity of thermoluminescence is nearly proportional to the amount of γ-radiation received, a considerable effort has been devoted to developing a practical means of measuring the exposure to γ-radiation (*23*). Lithium fluoride has been found to be the best crystal for this purpose, and it has been possible to measure exposures of 10–1000 roentgens and more with considerable ease and accuracy (*21*) by means of a portable photomultiplier tube and microammeter. Measurements of less than 1 roentgen have been made with a nonportable instrument. Lithium fluoride is stable, insoluble, and nondeliquescent, and ⅓ gram of artificial crystal grown by the Harshaw Chemical Company is sufficient for a measurement. The crystals used originally are about 1 cm^2, but more recently powdered lithium fluoride has been pressed into pellets, in a thin metal casing. Experiments are still under way to obtain greater uniformity, but successful tests with different laboratory and atomic radiations have been made. The dosimeter crystals, or pellets, are very small and can be placed in experimental apparatus, which is inaccessible to ordinary radioactivity meters. They have been used successfully by Marshall Brucer, of the Hospital of the Oak Ridge Institute of Nuclear Studies, to obtain measurements of internal radiation intensity in cancerous patients injected with radioactive isotopes. The crystals were swallowed by the patients, recovered one or two days later, and the accumulated dosage in roentgens was measured by matching the thermoluminescence intensity with that produced in the crystals by a known roentgen dosage.

Identification

The glow curves are characteristic of specific substances, with definite peaks at definite temperatures, similar in a sense to spectrograms with their lines of light at definite wavelengths. They are typical of crystalline materials that contain specific impurities and that have had definite heat treatments and physical histories. Thermoluminescence measurements are thus not suitable for analysis of chemical compounds, but they may find use in identification and control. For

example, different types of aluminum oxide will give different glow curves depending on impurities and previous heat treatment, but all samples of the same type will give the same glow curve. If one type is desired perhaps it could be selected on the basis of the glow curve. Again, the thermoluminescence glow curve of window glass will vary greatly with the impurities present, chiefly ferric oxide, but if a particular quality of glass is required the thermoluminescence glow curve may become a convenient control test to assure that each batch has the same quality. Limestones, ceramics, and optical crystals are among the materials that may be classified, identified, and controlled.

A collection of about 30 standard clays has been the object of an intensive cooperative research program involving many different measurements, such as viscosity, infrared absorption, and chemical tests. Some, but not all, of these standard clays exhibit characteristic thermoluminescence glow curves which merit further investigation. The nonorganic parts of certain soils should show characteristic glow curves that may be useful in identification and classification of soils.

The color of the light emitted on heating a previously irradiated material is often characteristic. Limestones give a yellow light, and dolomites give an orange light. The orange color may be helpful as a field test in identifying the presence of magnesium carbonate, although it may well be that the color is not related to the magnesium carbonate, but to an impurity associated with it.

Catalysis

It was suggested by Boyd and Hirschfelder (*22*) that thermoluminescence curves might be useful in evaluating the efficiency of surface catalysts. The same strains and lattice imperfections that permit adsorbed molecules to come within optimum distances from each other and bring about chemical reactions might also provide traps into which electrons could be driven by γ-radiation, and later released by heating. The intensity and nature of the thermoluminescence might be a measure of the catalytic efficiency. At least the thermoluminescence glow curve could be used as a criterion for controlling the preparation of a desired catalyst. A standard, successful catalyst should have a specific type of glow curve.

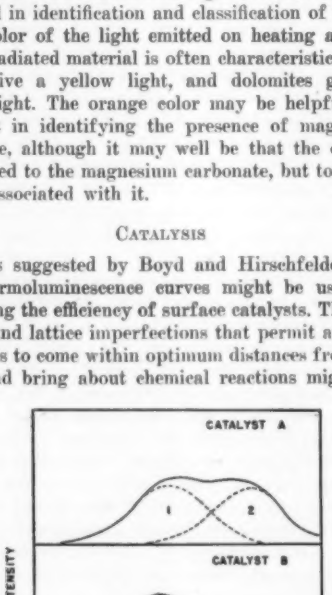

FIG. 2. Glow curves of catalysts.

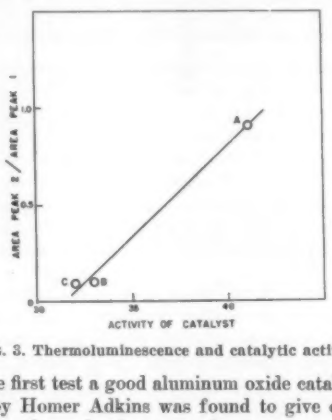

FIG. 3. Thermoluminescence and catalytic activity.

In the first test a good aluminum oxide catalyst prepared by Homer Adkins was found to give considerably more thermoluminescence than a poor catalyst of the same material. Several commercial catalysts have been examined, three of which are shown in Fig. 2. In this case the areas under the No. 2 peak are correlated with the catalytic efficiency, as shown in Fig. 3. Many catalysts, particularly of the gelatinous type, do not give any thermoluminescence, and in many others there is no apparent correlation, but enough catalysts have been examined to justify the conclusion that thermoluminescence is a new tool in catalyst evaluation and that it may become useful in researches to find new catalysts.

Radiation Damage

Most high-energy radiations are effective in producing damage to crystals. The investigation of this phenomenon is of importance in the design of nuclear reactors and in interpreting changes in crystal structure occurring in radioactive minerals over millions of years.

The fraction of γ-radiation energy that can be stored as trapped electrons in crystals is very small. With a photomultiplier tube calibrated with a thermocouple and standard lamp it was found that less than 1/10,000 of the energy of the absorbed γ-radiation was given out as thermoluminescence in lithium fluoride (*24*).

Thermoluminescence is one means of studying the storage of energy from high-energy bombardment and the crystal damage which can be produced by it. Atom displacements, if they occur, might lead to the storage of greater amounts of energy than that observed in thermoluminescence, but the means for

detecting heat are much less sensitive than the means for detecting light. Thermal analysis has failed thus far to reveal the storage of heat energy in γ-irradiated crystals, but more sensitive methods and greater exposures to radioactivity are now under investigation. In the case of certain metamict crystals containing considerable quantities of uranium the α-ray bombardment for millions of years has caused serious dislocations of the crystal lattice; so much so that x-ray diffraction patterns characteristic of crystals have been obliterated. When these minerals with accumulated radiation damage are raised in temperature, the stored energy is released as heat, and the x-ray diffraction pattern characteristic of a normal lattice is restored. In one case the energy released amounted to as much as 25 calories per gram (*24*).

Thermoluminescence of Rocks

Many natural rocks and minerals are thermoluminescent without exposure to x- or γ-rays in the laboratory. Most limestones crushed to millimeter size and dropped onto a faintly red-hot frying pan in a darkroom will emit a bright white or orange light for several seconds. After they are once heated and cooled, no light is emitted if they are heated a second time. However, brief exposure to x- or γ-rays will bring back the property of thermoluminescence, and by proper adjustment of the exposure the same intensity of thermoluminescence can be reproduced. Natural thermoluminescence has been frequently recorded in the geological literature (*13, 25, 26*) but it has generally been regarded as a curiosity. Some attributed the light to the burning of organic material. It has been repeatedly proved in the course of this investigation that the cause of the thermoluminescence is the presence of traces of uranium, thorium, and other radioactive elements contained in the rocks as impurities (*6, 27*). These radioactive impurities may be present only to the extent of one part per million or so, but they have been giving off α-, β-, and γ-rays for millions of years, and part of the thermoluminescence effect is cumulative. In fact, natural thermoluminescence of a rock is often a more sensitive means of detecting traces of radioactivity than is a Geiger counter or scintillometer. The relation between radioactivity and thermoluminescence in certain minerals had been earlier pointed out by Ellsworth (*25*), Kohler (*28*), and Alt and Steinmetz (*17*).

Surprisingly many rocks and minerals are naturally thermoluminescent. Over 3000 samples have been studied, mostly limestones and granites, of which about 75 per cent showed visible thermoluminescence, and still more would undoubtedly show thermoluminescence if measured with the most sensitive photomultiplier apparatus. Nearly all limestones and acid igneous rocks are naturally thermoluminescent. Calcium and magnesium carbonates show light-yellow to orange thermoluminescence, and potassium and sodium feldspars show white to blue-violet. These minerals are responsible for much of the thermoluminescence in the rocks examined, as, for example, in calcareous fossils or inclusions in shales, and in the cementing material between the grains of sandstone. Some fluorites containing uranium give a particularly brilliant thermoluminescence. Quartz, nepheline, topaz, halite, and spodumene react when they contain impurities of uranium, or thorium.

In a Boy Scout collection of 36 minerals over one third gave visible thermoluminescence. Out of 65 rock-forming minerals selected from the mineralogy laboratory's collection at the University of Wisconsin, 34 showed natural thermoluminescence. The intensity of light ranged all the way from that sufficient for reading a newspaper to "barely detectable."

All the minerals that displayed natural thermoluminescence could be made much brighter by additional exposure to γ- or x-rays, and many that did not give any detectable thermoluminescence were made thermoluminescent by a brief exposure to these rays. Of the 65 minerals just mentioned, 47 were thermoluminescent following exposure to γ-rays.

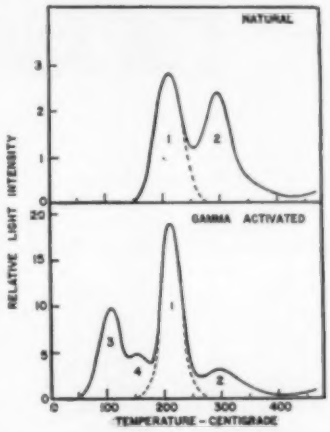

Fig. 4. Glow curves for Escabrosa limestone.

The increase in thermoluminescence resulting from a γ-radiation exposure of 140,000 roentgens is shown in the glow curves of Fig. 4 for the Escabrosa limestone. The No. 2 peak coming in at 300°C is about the same, but the No. 1 peak at 215° is seven times as intense. The No. 3 and No. 4 peaks at lower temperatures are fairly intense in irradiated thermoluminescence, but are completely missing in natural thermoluminescence, because the earth temperature has been high enough to drive all the displaced electrons out of their traps. The time elapsing between irradiation in the laboratory and testing is too short to permit any measurable loss. The high-

temperature peak at 300° involves so great a kinetic energy that most of the trapped electrons have remained trapped over the geological ages, and a still longer exposure to natural radioactivity would of course increase the intensity at peak No. 2 still higher—until saturation is reached.

The thermoluminescence of rocks is apt to be quite heterogeneous—some of the mineral constituents give off light when heated, and others do not. Thin specimens of limestones and granites have been polished and placed on a hot plate, with a camera focused on the surface. The light emitted by the heated specimen (below incandescent red heat) is sufficient to produce a photograph. An example is given in Fig. 5, where the calcareous fossils are clearly shown at the left. The light is due to the release of electrons that were originally dislodged by traces of uranium present and trapped in the calcium carbonate lattice of the fossils. The brighter picture at the right was produced by the same sample after an exposure to 140,000 roentgens of γ-rays. The thermoluminescence patterns displayed by granite surfaces commonly reveal spots of brighter light adjacent to inclusions of material of high radioactivity.

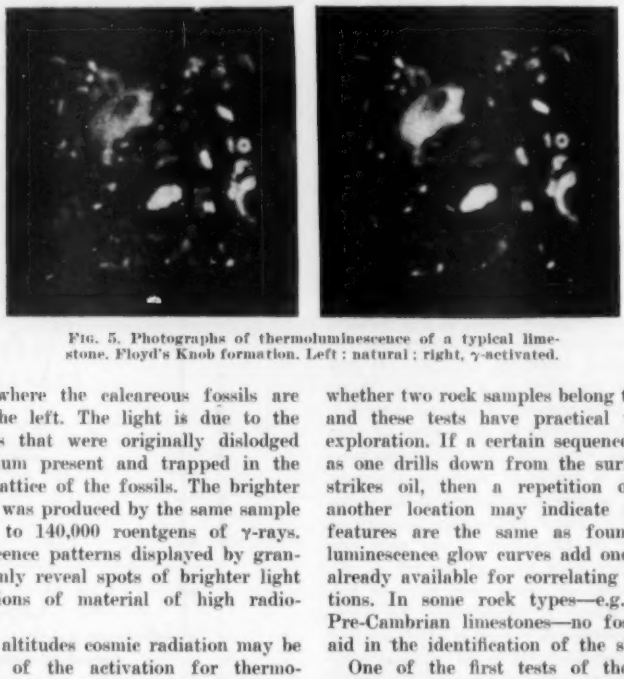

FIG. 5. Photographs of thermoluminescence of a typical limestone. Floyd's Knob formation. Left: natural; right, γ-activated.

Whereas at high altitudes cosmic radiation may be a factor in some of the activation for thermoluminescence, it becomes practically negligible in comparison with the activation caused by radioactivity in rocks below ground level or in rocks that contain one or more parts per million of uranium or thorium.

The thermoluminescence glow curves of rocks vary greatly—i.e., the heights of the peaks of the glow curves and the temperatures of their maxima change from rock to rock. The greater the concentration of uranium or thorium and the older the rock, the greater is the thermoluminescence, because the rock has been subjected to greater effects from radioactivity. The presence or absence of chemical impurities and the physical imperfections are, however, factors that may be just as important. The chemical environment at the time of crystallization and the physical effects of temperature and pressure on the rocks during their geological history have a great deal to do with the nature and intensity of the thermoluminescence.

STRATIGRAPHY

Because the glow curves are so responsive to chemical and physical conditions at the time a rock is formed, they can be used to determine whether two samples of sedimentary rocks were laid down at the same time in the same environment, even if the samples are widely separated geographically. Fossils and other criteria are now used to determine whether two rock samples belong to the same stratum, and these tests have practical value in petroleum exploration. If a certain sequence of strata is found as one drills down from the surface and eventually strikes oil, then a repetition of the sequence in another location may indicate that the geological features are the same as found before. Thermoluminescence glow curves add one more test to those already available for correlating sedimentary formations. In some rock types—e.g., volcanic ash and Pre-Cambrian limestones—no fossils are present to aid in the identification of the strata.

One of the first tests of the reliability of the application of thermoluminescence was carried out in a large limestone quarry, where the various strata can be differentiated visually for nearly half a mile. Thermoluminescence curves of ten samples taken from the same stratum across this half-mile face were identical in shape, but samples from other strata a few feet above or below gave entirely different glow curves (*29*).

Extensive studies have been made of thermoluminescence as a means of correlating limestones. For this purpose the glow curves obtained after excitation with γ-rays are more useful than the natural thermoluminescence curves, because many more peaks are available for identification in the low-temperature region—peaks that have been an-

nealed out of the natural thermoluminescence at earth temperatures. In general, there are four prominent peaks in the glow curves of most limestones. They occur at 120°–140°, 150°–190°, 210°–250°, and 290°–310°C. Saunders (*27, 29*) and Bergstrom (*30*) have made a special study of the correlation of limestones as revealed by their thermoluminescence glow curves. Particular attention has been given to the Pennsylvanian limestone outcrops in Iowa. Parks (*31*) has made a special study of subsurface stratigraphy as revealed by glow curves, using core samples from areas around southern Indiana and southern Illinois.

Age Determination

If suitable corrections can be made for chemical impurities and physical imperfections, and for the light absorption in the rock itself, one should be able to estimate the age of the rock from the thermoluminescence intensity and from the uranium or thorium content as determined from the α-ray activity of the sample. Each α-particle produces a given number of trapped electrons that will emit thermoluminescence. The light emitted should be proportional to the number of α-particles per year multiplied by the number of years since the crystal was formed. This method is much less reliable than the method of radioactive carbon for dating material, but the carbon method is satisfactory only for carbonaceous materials less than 25,000 years old. It is still less reliable than the lead-uranium, helium-uranium, potassium-argon ratios, but these radioactive methods also have their limitations. Any new method for dating rocks and minerals is well worth exploring, and progress is being made in the thermoluminescence method, which can give only the time since the mineral was last crystallized. It has been developed for limestones by Zeller (*32*) and for fluorites by Saunders (*33*). The α-activities are obtained with a scintillometer, applied by Ockerman (*34*) to a large area of the powdered rock. If the uranium content is only 1 ppm, the accuracy in determining the α-activities becomes the limiting factor. The area under a selected high-temperature peak in the natural glow curve is used for comparison—or, in another method, the electron traps thought to be produced by α-particles are filled by saturating with γ-rays. The light absorption of each sample is determined experimentally so that corrections can be made for light losses in samples that are not completely transparent. Limestones of known geological ages are used for a calibration scale.

The greatest uncertainties lie in the presence of chemical impurities and imperfections in the crystal lattice, which will increase or decrease the thermoluminescence. It is hoped that better results will be obtained through the use of a 1-curie polonium source, lent by the Atomic Energy Commission, with which an α-ray bombardment can be given to a thin surface layer in a second, which is equivalent to a million-year bombardment in the limestone with its mere trace of uranium. With this technique it should be possible to cancel out the effects of impurities; and, except for uncertainties in the radiation damage, the time required for the polonium source to match the natural thermoluminescence of the rock would give a direct measure of the α-particles emitted since the rock was formed. Knowing the rate of α-particle emission per hour and per year in the rock, the time required to produce the observed thermoluminescence could be easily calculated.

The possibility of estimating the dates at which limestones and ancient pottery were heated to high temperatures is now being explored. Many other applications of thermoluminescence to various laboratory techniques and applied problems are under investigation.

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News and Notes

Scientists in the News

Philip H. Abelson, chairman of the Biophysics Section, Department of Terrestrial Magnetism, Carnegie Institution of Washington, has been appointed director of the institution's Geophysical Laboratory, effective Sept. 1. **George W. Morey** will continue as acting director until that date, and will then devote full time to his own research.

Donald G. Anderson, of the Council on Medical Education and Hospitals of the American Medical Association, has been appointed dean of the University of Rochester School of Medicine and Dentistry. Dr. Anderson will succeed **George Hoyt Whipple,** who will resign on June 30.

Norman Q. Brill, psychiatrist and medical educator, has been selected to head a coordinated mental hygiene program by the UCLA School of Medicine and the State Department of Mental Hygiene. Dr. Brill will serve as chairman of the Department of Psychiatry at the new Medical Center and as Director of the State Department of Mental Hygiene unit to be built near the Los Angeles campus.

James E. Castle has joined Foote Mineral Company as manager of the Lithium Mining and Milling Division at Kings Mountain, N. C. Mr. Castle had been assistant plant manager of the Balmat Mill for St. Joseph Lead Company since 1943.

K. K. Chen, director of pharmacologic research, Lilly Research Laboratories, and professor of pharmacology, Indiana University, delivered the annual Bardeen Memorial Lecture of the Phi Chi Medical Fraternity at the University of Wisconsin School of Medicine on Apr. 1.

Willard F. Crosier, associate professor, Division of Seed Investigations, New York State Agricultural Experiment Station, will be an official U. S. delegate to the tenth congress of the International Seed Testing Association in Dublin, May 25. He will present the report of the Committee on Seed-borne Diseases and Pests, of which he is chairman.

Arthur H. Davison has been appointed chief psychologist at the Milwaukee County Hospital for Mental Diseases, and has resigned from the Veterans Administration Hospital, Perry Point, Md.

H. Trendley Dean, who helped discover that fluorine compounds in drinking water can reduce tooth decay in children, retired from the U. S. Public Health Service Apr. 1. **Francis A. Arnold, Jr.,** has been named to succeed Dr. Dean as director of the National Institute of Dental Research.

S. Norman Feingold, executive director of the Jewish Vocational Service of Greater Boston, and president of the Greater Boston Vocational Guidance Association, has been made a member of the President's Committee on Employment of the Physically Handicapped.

F. A. Fox, formerly deputy director of the British Welding Research Association, has been appointed superintending scientist in charge of the Chemical and Physical Research Laboratories, Australian Government Department of Supply, Maribyrong, Melbourne.

Ira N. Gabrielson, president of the Wildlife Management Institute, has received the Leopold Memorial Medal of the Wildlife Society, for service to wildlife conservation.

Jagat J. Ghosh, fellow of the International Anaesthesia Research Foundation, has joined the Montreal General Hospital Research Institute to work with J. H. Quastel. Dr. Ghosh was formerly with the Nutrition Research Unit, Indian Council of Medical Researeh, New Delhi.

J. Linsley Gressitt has been appointed entomologist at Bernice P. Bishop Museum, Honolulu, where he will direct the project "Insects of Micronesia." Dr. Gressitt has been with the Pacific Science Board studying the ecology of the coconut rhinoceros beetle, and was formerly with Lingnan University and the University of California Division of Biological Control.

Joel H. Hildebrand, emeritus professor of chemistry at the University of California, gave the Edgar Fahs Smith Memorial Lecture in Chemistry, sponsored by the Philadelphia Section of the American Chemical Society, and the University of Pennsylvania.

A. Bradford Hill, professor of medical statistics, London School of Hygiene and Tropical Medicine, University of London, was guest lecturer on Mar. 20 at the National Institutes of Health, Bethesda, Md. Dr. Hill spoke on "The Philosophy of the Clinical Trial."

John A. Hipple, chief of the Atomic Section, National Bureau of Standards, has been named director of the Mineral Industries Experiment Station at the Pennsylvania State College, effective Mar. 1. Dr. Hipple fills the vacancy created by the retirement of **Alfred W. Gauger.**

Charles B. Huggins, professor of surgery, University of Chicago, will give the twentieth E. Starr Judd lecture in surgery at the University of Minnesota, May 7. Dr. Huggins' subject will be "The Endocrinology of Mammary Cancer."

Donald F. Jones, head of the Genetics Department, Connecticut Agricultural Experiment Station, has been granted a three months' leave of absence to serve as visiting professor of genetics at the University of Washington, Seattle. Dr. Jones will conduct

a course on general genetics, and a graduate seminar on theoretical genetics, during the spring term.

Gabriel Langfeldt and **Isadore Snapper** have been appointed lecturers in the University of Illinois College of Medicine, with the rank of professor, and **David S. Ruhe** has been named clinical assistant professor of medicine. Dr. Langfeldt, now engaged in psychiatric research at the Manteno State Hospital, will serve as lecturer in psychiatry. Dr. Snapper, educational director of Cook County Hospital, will lecture in the Department of Medicine. Dr. Ruhe is director of the Medical Audio-Visual Institute of the Association of American Medical Colleges.

Fritz London, of the Department of Chemistry, Duke University, has been selected to receive the Lorentz Medal of the Royal Netherlands Academy of Sciences. The medal will be presented at a meeting of the academy's Section for Science on June 27.

George N. Papanicolaou, professor of anatomy at Cornell University Medical School, has been selected to receive the Leonard A. Wien Award, in recognition of his outstanding research in cancer cytology.

Ernest A. Remesch has joined Foote Mineral Company as superintendent of the new lithium processing plant at Sunbright, Va. Dr. Remesch was formerly with Melson Fertilizer Company, Georgetown, Del.

Elmer H. Schulz has been promoted to director of research, and **Maurice J. Day** to assistant director for program development, at Armour Research Foundation of Illinois Institute of Technology. Dr. Schulz was formerly manager of the foundation's Physics and Electrical Engineering Division, and Dr. Day was manager of the Materials and Processes Division.

M. Michael Sigel, assistant professor of virology, University of Pennsylvania School of Medicine, has joined the Virus and Rickettsia Section of the Communicable Disease Center, U. S. Public Health Service at Montgomery, Ala., as chief of the Virus Identification and Special Research units.

D. B. Steinman, bridge engineer, has been named Chevalier de l'Ordre du Mérite Scientifique by the French government. Dr. Steinman also holds the Cross of Lorraine, and has been similarly honored by the governments of Belgium, Italy, and Greece.

Bernet S. Swanson, assistant professor of chemical engineering at Illinois Institute of Technology, has been appointed head of the department. Dr. Swanson replaces **J. Henry Rushton,** who will continue as professor in the department, and will devote his additional time to research, writing, and consultation.

Max E. Tyler, bacteriologist at Camp Detrick, Frederick, Md., has been appointed head of the new Department of Bacteriology at the College of Agriculture, University of Florida.

Vernon George Vernier has been appointed research associate, Pharacodynamics, at Sharp & Dohme. Dr. Vernier was formerly instructor in pharmacology, University of Illinois College of Medicine, and will continue his research in neuropharmacology.

John Francis Waight, engineer of the West Midlands Gas Board, has been awarded the 1952 W. H. A. Robertson Medal by the Institute of Metals, London, for his paper "Gas Equipment for the Thermal Treatment of Non-Ferrous Metals and Alloys," published in the *Journal* of the institute. Awards have also been made by the institute to **R. D. Stacey,** University of Birmingham, and **G. Thomas,** of Cambridge University, for essays submitted in its Students' Essay Prize Competition.

T. Wayne Warren has joined Ethyl Corporation as supervisor of research in refinery technology at the Detroit laboratories, where he will be associated with research in fuel technology. Mr. Warren was formerly with Humble Oil and Refining Company, and has served as aviation fuels specialist for the Petroleum Administration for Defense in Washington.

Education

The 1953 Falk-Plaut Lectures, at **Columbia University,** were given by Ilya Prigogine, professor of physical chemistry and head of the Division of Advanced Thermodynamics and Statistical Mechanics at the University of Brussels. During his three weeks' residence at Columbia, Dr. Prigogine discussed "Statistical Thermodynamics of Solutions and Molecular Theory of Liquid Helium" and "Thermodynamics of Irreversible Processes." The lectureship was created through a gift of $100,000 from the estate of Amy Plaut Falk. The bequest was divided equally between the Department of Chemistry and the College of Pharmacy.

The annual **Cornell Summer Laboratory Course** in Techniques and Applications of the Electron Microscope will be given June 15–27 in the Department of Engineering Physics. The course, under the direction of Benjamin M. Siegel, will present James Hillier and C. E. Hall as guest lecturers. Applications should be addressed to Dr. Siegel at Cornell.

Massachusetts Institute of Technology offers the following summer courses: Food Technology, June 29–July 17, under Bernard E. Proctor; Lubrication Engineering, June 16–26, under Brandon G. Rightmire; Principles of Textile Research, July 6–July 31, under Edward R. Schwarz. Ernest H. Huntress is director of the summer session.

Stanford University School of Medicine will present the following speakers in its course of popular medical lectures: Ernest Jawetz, Mar. 31, "Influenza: Past and Present;" John A. Anderson, Apr. 9, "How to Let Children Grow Up;" William H. Northway, Apr. 17, "Rehabilitation of the Polio Patient;" and Windsor C. Cutting, Apr. 27, "Sleep and Sleeping Pills."

Grants and Fellowships

AAAS Research Grants have been awarded to the following academies of science: Indiana, for Frank Welcher, of Indiana University, and Benjamin Moulton, of Butler University; Washington (D. C.), for Edward Haeskaylo, of the Botanical Society of Washington; and Wisconsin, for F. C. Seymour, of Tomahawk.

The **Air Force** Office of Scientific Research, Air Research and Development Command, has established research projects at the following universities: Ohio (William D. Huntsman), Harvard (M. Kent Wilson), Pennsylvania (B. R. Russell), Columbia (B. O. Koopman), Caltech (Fritz Zwicky and D. S. Clark), MacMaster (H. E. Duckworth), Miami (Howard L. Ritter), Stanford (Flügge-Lotz), Iowa State (D. L. Hall), Fresno State (Robert M. Kallo), Pennsylvania State (H. G. Lew), Illinois Institute of Technology (Paul L. Copeland), Ohio State (Henry B. Mann), Alfred (R. C. Turnbull), Texas (M. J. Thompson), and Virginia Polytechnic (R. W. Truitt).

The **Isaiah Bowman School of Geography** at The Johns Hopkins University offers a $4000 postdoctoral teaching fellowship in geography. Teaching duties will not exceed four hours. Apply to the chairman of the school, Baltimore 18, Md.

The **Jane Coffin Childs Memorial Fund for Medical Research** has awarded a $20,000 grant-in-aid to a University of Rochester medical research group headed by Elmer H. Stotz, professor of biochemistry. The grant will support a project in which the team will attempt to discover more about a new and as yet unnamed enzyme discovered by Dr. Stotz and his co-workers, to define the role of hormones in metabolism, and to find out what significance the new enzyme has to the general problem of growth.

Applications for **Fulbright** funds for university lecturing in Germany and Finland and for lecturing and advanced research in South Africa, Southeast Asia, and the Pacific must be postmarked no later than *Apr. 15.* Full information and application blanks may be obtained from the Conference Board of Associated Research Councils, Committee on International Exchange of Persons, 2101 Constitution Ave., N.W., Washington 25, D. C.

The **John and Mary R. Markle Foundation** has appropriated $630,000 to be granted at the rate of $6000 annually for five years to 21 U. S. and Canadian medical schools where Scholars in Medical Science will teach and carry on research. This brings to a total of over $3,200,000 the amount appropriated toward the scholar program since it was begun in 1948.

The **University of Virginia** has received a gift from an alumnus for two postdoctoral and four predoctoral fellowships in the Department of Physics. Stipends range from $2500 and tuition to $5000.

Meetings and Elections

The **American Institute of Chemical Engineers** is planning an international meeting for June 20–25, 1954, at the University of Michigan. D. L. Katz is in charge of the technical program, and R. R. White will be general chairman.

A group of students of philosophy has organized **ARCHAI,** a society for the advancement of philosophy. ARCHAI will sponsor informal discussions of the problems and issues that engage the interest of intelligent men and women and will publish a journal, *The Modern Mind.* The first meeting of the new society will be held Apr. 19, in 301 Philosophy Hall, Columbia University, at 7:30 P.M. Irwin Edman, Johnsonian professor of philosophy at Columbia, will address the gathering, and informal discussion groups will be arranged. Further information may be obtained by addressing the society at P. O. Box 147, Manhattanville Station, 309 W. 125th St., New York 27.

The **Billings Geological Society** will hold its annual field conference during the first part of September in the little Rocky Mountain area of north-central Montana, with headquarters and registration at Zortman. Two full days will be given to the study of several sections extending from the Pre-Cambrian to the Upper Cretaceous. Because of inadequate accommodations, the society encourages the registration of men only, with participation limited to 200. Paul McGovney, of Honolulu Oil Corporation, Billings, is general chairman. Those who wish to attend the conference should write immediately to J. L. Cramer, Stanolind Oil and Gas Company, 526 Securities Bldg., Billings.

A **Colloquium of College Physicists** will be held at the University of Iowa, June 17–20. E. U. Condon, AAAS president, will give a series of four lectures on the general subject of "The Physics of the Glassy State."

The **Executive Board of Unesco** has elected Ronald Adam, of the United Kingdom, chairman for the next two years. Frans Bender (Netherlands) and S. M. Sharif (Pakistan) were elected vice-chairmen. Geronima Pecson (Philippines) was elected chairman of the board's Programme Commission, Luther Evans (USA) chairman of the Finance Commission, and Henri Laugier (France) chairman of the External Relations Commission.

An **International Symposium on Chemistry of Natural Products** will be held at Wayne University, July 29–30. Gilbert Stork (Columbia University), D. H. R. Barton (Birckbeck College, University of London), O. Jeger and H. Heusser (Technische Hochschule, Zurich), K. J. Brunings (Chas. Pfizer & Co.), Marshall Gates (University of Rochester), G. W. Kenner (Cambridge University), and E. R. H. Jones (Uni-

versity of Manchester) will be among the participants. Address all inquiries to Carl Djerassi, Department of Chemistry, Wayne U, Detroit 1.

The **Minnesota Academy of Science** will hold its annual meeting May 1–2 at Macalester College, St. Paul. Features of the meeting will be a symposium on "Dating of the Age of the Earth and its Biota by Modern Methods" and a demonstration of scientific projects by the Junior Academy.

The **National Vitamin Foundation** has re-elected Norman Jolliffe, of New York City, president, and Robert S. Goodhart vice president and scientific director. New vice presidents are R. W. Albright, W. R. McHargue, and John E. McKeen.

The second annual meeting of the **Persian Gulf Medical Society** will be held at Dhahran, Saudi Arabia, Dec. 2–3. Neal J. Conan Jr. will act as chairman, and the topic for discussion will be "Diseases Endemic to the Persian Gulf Area."

The **Rocky Mountain Association of Geologists** has elected N. Wood Bass, of the U. S. Geological Survey, president, E. C. Simpson, and A. J. Crowley vice presidents, and Jerry M. Ewers secretary-treasurer.

The **Sociedade Brasileira de Geologia** meeting in Porto Alegre, has elected the following officers: president, Aleeu Fabio Barbosa; vice presidents, Paul de Castro Nogueira and Emmanoel Azevedo Martins; secretary, Rui Ribeiro Franco; treasurer, Nicolino Viola. The next congress of the society will be held in Terezina.

The **Society of Exploration Geophysicists** has elected Roy L. Lay, of the Texas Company, Houston, president; Karl Dyk, of Stanolind Oil and Gas Company, Tulsa, vice president; and Bart W. Sorge, secretary-treasurer. Milton B. Dorbrin has been named editor for a two-year term.

Miscellaneous

The **American Chemical Society,** at its meeting in Los Angeles, awarded the 1953 Garvan medal to Leonora N. Bilger, chairman of the Department of Chemistry in the University of Hawaii. Among other honors were the presentation of the Fritzsche award in the chemistry of essential oils to Max Stoll, of Firmenich & Company, Geneva, Switzerland; the Paul-Lewis Laboratories award in enzyme chemistry to Earl R. Stadtman, of the National Institutes of Health; and the Scientific Apparatus Makers award in chemical education to Howard J. Lucas, of California Institute of Technology.

Recent visitors at the USDA **Eastern Regional Research Laboratory,** Philadelphia, included Eladio Aranda Heredia, of Madrid; Rene Welter, of Angleur, Belgium; F. H. Reuter, of New South Wales University of Technology; and F. B. Shoreland, director of the Fat Research Laboratory, Department of Science and Industrial Research, Wellington, N. Z.

Arthur D. Little, Inc., has appointed the following to its staff: Hamilton R. James and Richard A. Stephan (Business Research Group); Robert L. Stern (Technical Economic Survey Group); Wayland S. Bailey and James Farrell (Mechanical Division); Richard S. Brenneman and Donald B. Lindsay (Products and Methods Group).

Headed by James R. Killian, Jr., **Massachusetts Institute of Technology** president, a delegation of ten members of the Administrative Council began a three-day conference Mar. 23 with about 125 **California Institute of Technology** staff members. Problems of mutual interest concerning curriculum, policy, procedures, finance, and operations were discussed. Caltech representatives will visit MIT next year.

Recent visitors from abroad at the **National Bureau of Standards** included Giuseppe Dilda, University of Torino, Italy; Masao Yoshiki, Tokyo University; Magdalena Startz, K. G. Niederpleis über Sieburg, Germany; S. Ingvar Svensson Gothenburg, Sweden; W. H. Steel, Australian National Standards Laboratory, Sydney; C. J. Bouwkamp, Eindhoven, Netherlands; Leonard S. Beckett, N. S. W., Australia; Igal Talmi, Israel; Mukti Prosad Mukheji, New Delhi, India; G. Pearmain, London; and Maurice Bonzel, Jean Chaudouet, Pierre Husson, Michel Jeanmaire, Maurice Laudet, Emile Robbe, and Johannes Wehrenberg, all of France.

Otto Neugebauer, of Brown University, has been awarded the $5000 Dannie Heineman Prize, for his book *The Exact Sciences in Antiquity,* published in 1952 by the Princeton University Press. The award is given every three years for an outstanding book in the mathematical or physical sciences.

Stanford Research Institute has organized a party of research executives who sail from New York Apr. 22 to spend a month in a tour of technical and research centers in Italy, Switzerland, and France, with a view to utilizing foreign laboratories for their research programs. Tour leader will be Weldon B. Gibson, SRI director of economics research and manager of the International Division.

The **Edgar D. Tillyer Medal,** a biennial award created by the American Optical Company, will be given by the Optical Society of America for outstanding contributions in the field of vision. Presentation of the dies for the medal was made during the society's annual meeting at a banquet at which Dr. Tillyer was a guest. The medal is a tribute to the achievements of his 37-year career in research for American Optical, and will be awarded for the first time in 1954.

The **Tropical Research Foundation** is sending a group of scientists under the direction of Viola Mae Young, former parasitologist of Cook County Hospital, Chicago, to Jamaica and Curacao to study amebiasis and infantile diarrhea. Dr. Young replaces Oscar Felsenfeld, who has been called for active duty in the U. S. Army Medical Corps.

Technical Papers

Some Biometric Observations on Cacao Fruit

J. R. Kuppers

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During a program directed toward the selection of cacao trees of superior characteristics as parent stock for vegetative propagation of new planting material, a large amount of data derived from various physical measurements on cacao fruit was accumulated. These data were examined statistically to obtain a simple measurement that would serve as an index to the yield of dry cacao from an average fruit of a particular tree. The yield of dry cacao per tree is dependent upon the fruit produced and the weight of dry cacao per fruit. Direct determination of the former is relatively simple when compared with the latter. Therefore, a good indicator of the weight of dry cacao per fruit would be of value in selecting high-yielding stock.

The measurements analyzed in this study were made on samples containing 6–15 (an average of 10) fruit per sample. Trees were selected in the field on the basis of fruit counts and apparent disease resistance.

TABLE 1

STATISTICS OF FOUR ATTRIBUTES MEASURED ON 70 SAMPLES* OF FRUIT†

	Av wt individual fruit (g)	Av wt individual dry seeds (g)	Av no. seeds/ fruit	Av wt dry cacao/ fruit (g)
Mean	551	1.32	34	45
Median	517	1.27	34	43
Range	314–892	0.78–2.31	14–42	22–84
Coefficient of variation	28%	23%	15%	22%

* 6–15 (av 10) fruit per sample.
† Fruit harvested from trees in an old seedling population on the basis of fruit counts and apparent disease resistance.

These trees, 20 or more years of age, were located on farms representing the greater portion of plantings in the Bocas del Toro Province of Panama. They were derived from hybridization of Forestero and Criollo varieties of *Theobroma cacao*, with Forastero characteristics predominating. The fruit samples were carefully harvested at maturity (after the pulp surrounding the seeds became semiliquid and before the seeds sprouted) and were transported immediately to a laboratory, where the seeds were removed, processed, and dried so as to yield cacao containing $7 \pm 1\%$ shell and $6 \pm 1\%$ moisture.

The following measurements were made on 70 samples of fruit: (1) average weight of individual fruit, (2) average weight of individual dry seeds, (3) average number of seeds per fruit, and (4) average weight of dry cacao per fruit. The mean, median, range, and coefficient of variation of measurements of these four attributes were computed. As seen in Table 1, the average number of seeds per fruit was the least variable attribute, and the mean coincided with the median. The variations of the remaining three attributes were considerably greater and their means were higher than their medians. This undoubtedly means that trees bearing unusually heavy fruit, seed, or yield of dry cacao per fruit were selected more frequently than trees with unusually low values for these attributes.

TABLE 2

RELATIONSHIPS OF FOUR ATTRIBUTES MEASURED ON 70 SAMPLES OF CACAO FRUIT

		Av wt individual fruit	Av wt individual dry seeds	Av no. seeds/ fruit
Av weight of dry cacao/ fruit	Coefficient of correlation	0.59*	0.86*	0.50*
	Coefficient of regression	0.047†	34‡	1.30§

* $P = 0.01$.
† g dry cacao/g of fruit.
‡ g dry cacao/g dry seed.
§ g dry cacao/seed.

The relationships of average weight of dry cacao per fruit to the average weight of individual fruit, average weight of individual dry seeds, and number of seeds per fruit are shown by coefficients of correlation and regression in Table 2. The average weight of dry cacao per fruit is significantly correlated with the remaining three attributes. The most dependable index to this factor, however, is the average weight of individual dry seeds. In attempting to predict the average weight of dry cacao per fruit from the average weight of individual dry seeds, the standard error of estimate is 6 g. This is one half the standard deviation of the former attribute.

Pound (*1, 2*) investigated the variability of numerous physical measurements on cacao in Trinidad, but he made no attempt to correlate the attributes discussed in this study. To the writer's knowledge, no simple index to the yield of dry cacao per fruit has been developed. Nevertheless, those concerned with the selection of high-yielding cacao are aware of the importance of considering this factor of over-all yield.

Since dry seed weight is closely correlated with yield of cacao per fruit, we can conclude that the size of the fresh seeds as judged visually in the field is also a good index to this factor. If we use large seeds (along with fruit production of the tree) as a cri-

terion for selection of high-yielding trees, we satisfy at the same time the desire of chocolate manufacturers for large, plump seeds.

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The Enzymatic Conversion of Lactose into Galactosyl Oligosaccharides

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The enzymatic synthesis of oligosaccharides from the disaccharides, sucrose and maltose, has been reported from several laboratories (*1–5*). Experiments with labeled substrates (*6, 7*) have shown that these oligosaccharides arise through transfructosidation and transglucosidation reactions. In this communication, we shall report preliminary studies on the enzymatic conversion of lactose into a series of galactosyl oligosaccharides. Evidence from tracer experiments indicates that a transgalactosidation mechanism is involved in the synthesis of the new oligosaccharides. From a consideration of the products of partial acid hydrolysis of the oligosaccharides and their aldonic acid derivatives, it appears that two of the new compounds are disaccharides (glucose-galactose and galactose-galactose) and two are isomeric trisaccharides (glucose-galactose-galactose).

Ten g CP lactose in 100 ml of water was treated with 100 ml of a 2% solution of a yeast enzyme preparation.[1] At the end of 24 hr the digest was heated in a boiling water bath for 5 min. The products in the digest were resolved by paper chromatography (*8*). Examination of the paper chromatogram (Fig. 1) revealed the presence of the new oligosaccharides. These oligosaccharides were not synthesized from glucose and galactose since an enzymatic digest of these substrates contained no new compounds. Further, a blank of the enzyme and the lactose showed that the oligosaccharides were not present in the original solutions. It is noted, however, that the enzyme blank contained two monosaccharides (fructose and glucose) as contaminants. Dialysis of the enzyme removed not only the monosaccharides but also some essential cofactor of the enzyme.

The new oligosaccharides (I, II, III, and IV) were isolated by paper chromatographic procedures previously described (*7*). Hydrolysis of the pure compounds in 0.1 *N* HCl showed that Compounds I, III, and IV are composed of glucose and galactose residues and that Compound II is composed of galactose residues. As judged from the intensity of the spots on the paper chromatogram, the glucose-galactose ratios appeared to be 1:1 for Compound I and 1:2 for Compounds III and IV.

[1] The yeast concentrate "Lactase B" was kindly supplied by Rohm & Haas Co., Philadelphia, Pa. This concentrate possessed the transferring activity described in this report, as well as hydrolytic (lactase) activity.

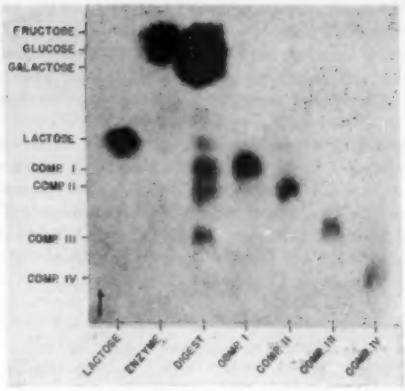

Fig. 1. A multiple ascent paper chromatogram of the lactose digest, of lactose and enzyme controls, and of the pure galactosyl oligosaccharides.

Two further lines of evidence point to the structure of the oligosaccharides. First, the apparent R_F values of the pure compounds (Fig. 1) are typical of oligosaccharides composed of two or three monosaccharide units joined through 1,4 or 1,6 glycosidic bonds (*7, 9*). Second, partial acid hydrolysis of the compounds and their aldonic acids yields the reducing products listed in Table 1. These hydrolytic products have been tentatively identified by a comparison of their R_F values with those of pure reference compounds. The structures suggested by these findings are: glucose-6,1-galactose for Compound I, galactose-6,1-galactose for Compound II, glucose-4,1-galactose-6,1-galactose for Compound III, and glucose-6,1-galactose-6,1-galactose for Compound IV.

There is a marked similarity in the mode of action

TABLE 1

Reducing Products Obtained on Partial Acid Hydrolysis of the Galactosyl Oligosaccharides and their Aldonic Acid Derivatives

Oligosaccharides	Reducing products
Compound I	Glucose, galactose
Aldonic acid of Compound I	Galactose
Compound II	Galactose
Aldonic acid of Compound II	Galactose
Compound III	Glucose, galactose, lactose, Compound II
Aldonic acid of Compound III	Galactose, Compound II
Compound IV	Glucose, galactose, Compound I, Compound II
Aldonic acid of Compound IV	Galactose, Compound II

of the *A. oryzae* transglucosidase (*7*) and the enzyme involved in these reactions. In the former, glucose units of maltose are transferred to the cosubstrates glucose, maltose, isomaltose, and panose, whereas in the latter galactose units of lactose are transferred to the cosubstrates glucose, galactose, lactose, and Compound I. Radioactive cosubstrates have been used to substantiate the proposed transgalactosidic mechanism of action of the new enzyme. Thus C^{14}-glucose included in the digest appeared in Compounds I and IV, and C^{14}-galactose appeared in Compound II. These studies are being continued in our laboratories.

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Chromatographic Separation of Estrone, Estradiol, and Estriol

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The estrogens appear to be present in human and cattle blood in extremely small concentrations, of the order of 3–8 μg/l whole blood (*1, 2*). The determination of the three natural estrogens in blood requires quantitative methods for their separation and estimation. The object of this report is to present a method suitable for routine use for the quantitative separation of estrone, estradiol, and estriol at this microlevel. The following work has been carried out with pure crystalline estrogens, as a preliminary to the application of the method to the estrogens in blood.

Partition chromatography has been used for the separation of closely related compounds that show a difference in partition coefficients (*3*). Recently a method for the separation of estrone and estradiol by partition chromatography was reported (*4*). A NaOH solution adsorbed on Celite forms the stationary phase, and benzene the moving phase. A similar system, also using NaOH-Celite and benzene, was used earlier by another group (*5*) for the separation of certain estrogen isomers. The method proposed by the British workers proved to be more effective in our hands in accomplishing the estrone-estradiol separation.

It seemed valuable from the standpoint of the number of manipulations, time, and magnitude of losses, to effect a separation of all three estrogens on one column in one operation. Because of the more hydrophilic character of estriol, as compared with estrone and estradiol, it is not eluted from the NaOH-Celite phase by benzene. It was recognized that a more favorable partition system was necessary for the separation of estriol. This can be achieved by two methods: a change in the moving phase, and/or a change in the stationary phase. A separation of all three estrogens has recently been reported by the British group (*6*), utilizing a change in the moving phase to accomplish the separation of estriol. The eluent used was chloroform-butanol (3 : 1). This procedure, or the use of acetone, ethylene dichloride, or methanol as eluents, did not prove as satisfactory as the method reported below, because of the elution of a large amount of butanol-soluble material in the estriol fraction. Accordingly, the second approach, a change in the nature of the stationary phase, has been used in the technique developed in our laboratory. It was discovered that estriol could be eluted by benzene from a less alkaline stationary phase consisting of Celite to which water rather than NaOH had been added. It occurred to us that after use of the NaOH-Celite column to separate estrone and estradiol, it could be changed to the less alkaline water-Celite or $NaHCO_3$-Celite column by reaction with gaseous HCl or CO_2. Estriol is then readily eluted by benzene from these systems. These modifications were carried out successfully, and, because of the greater safety in handling CO_2, it has been used routinely to modify the partition characteristics of the column.

The chromatographic conditions of Swyer and Braunsberg (*1*) were used, and the columns were prepared according to the careful description of Haenni, Carol, and Banes (*7*) for preparations of this type. A West-type straight condenser (ID, 10.8 mm), with stopcock at the reciving end, was employed as a chromatographic tube. This allowed the temperature of the column to be controlled at 24° ± 2° C by circulation of water of the appropriate temperature through the condenser. The column is filled with benzene (CP benzene-thiophene–free is shaken 6 times with sulfuric acid and redistilled), and fine glass wool (Fiberglas, Corning) is packed into the constriction above the stopcock. Three g Celite 535 (Johns-Manville) and 25 ml benzene in a small beaker are thoroughly mixed with 2.4 ml 2.3 *N* NaOH for several minutes. The stopcock is opened enough to permit slow drainge, and the Celite mixture is transferred to the tube in small portions, with a spatula. A flocculent suspension is formed by slowly working the packing rod (a glass rod flattened at one end to a circular head with a clearance of 1.0 mm in the adsorption tube) up and down as a piston through the Celite mixture. The Celite is then gently compressed with the rod to form a uniform pack with a sharply defined level surface. The mixture fills the tube to a height of 125 mm ± 5 mm.

Suitable aliquots (containing 2–10 γ) of solutions

of crystalline estrone,[1] estradiol,[1] and estriol[2] in alcohol-toluene (1 : 19) are transferred to a small round-bottom flask, and the solvent is evaporated to dryness *in vacuo* at room temperature. The residue is dissolved in a small volume (1–2 ml) of benzene and discharged onto the column just as the benzene drains below the top surface of the Celite. The transfer is completed by repeating with an additional portion of benzene. The tube is then filled with benzene and the stopcock adjusted so that a flow rate of 2.5–3.0 ml/min is attained.

Estrone exhibits the greatest rate of elution and appears in the eluate after a forerun of 30 ml of benzene (Fraction I). It is completely recovered in the following 80 ml of benzene (Fraction II). A clear zone of 10 ml of benzene (Fraction III) follows before the appearance of estradiol. An additional 90 ml of benzene (Fraction IV) is sufficient to elute the diol. This elution can be completed in a few minutes by applying N_2 under pressure to the column. Estriol cannot be eluted from the NaOH-Celite system by benzene, and the system is therefore modified to permit its recovery. Gaseous CO_2 is bubbled up through the chromatographic column at the rate of 30 cc/min for a period of 5 min; 100 ml of benzene (Fraction V) then elutes the estriol. The elution of estriol can also be facilitated by the use of N_2 or CO_2 under pressure to force the benzene through the column. The effluents are collected in graduated cylinders, transferred to round-bottom flasks, and evaporated to dryness under reduced pressure at bath temperatures not exceeding 50° C.

The residues are dissolved in a measured volume of ethyl ether, (purified daily by shaking with ferrous sulfate and redistilling), and an aliquot is transferred to a fluorometer tube for analysis. The ether can be evaporated to dryness in 15–20 sec on a warm (60° C) water bath, and the ether vapors exclude air from the tube during evaporation. This step avoids oxidative losses which occur when alcohol, the usual diluent in steroid procedures, is employed with or without the use of a stream of N_2 (*8*). Two tenths ml alcohol-toluene (1 : 19) is added to the residue in the test tube, and the estrogens are analyzed by the fluorimetric procedure of Engel *et al.* (*9*). The fluorescence is measured in a Colemen Model 12 photofluorometer with a lamp filter transmitting at 436 mμ (Corning #3389 and Corning #5113 glass filters) and photocell filter transmitting at 525 mμ (Baird 525 mμ interference filter + Corning #3385 glass filter). Standards were run in each fluorometric analysis. Estrone, estradiol, and estriol are the standards of comparison for the fluorescence exhibited by Fractions II, IV, and V, respectively.

The entire collection period requires either 1.0 or 2.0 hr, depending on whether pressure or gravity flow is used in the elution of estradiol and estriol; preparation of the column, 0.5 hr; fluorimetry, 0.5 hr; and evaporation of the benzene from the eluates, 0.5–0.75 hr. Thus, in either 3 or 4 hr, a quantitative separation and estimation of microquantities of estrone, estradiol, and estriol can be accomplished.

TABLE 1

PARTITION CHROMATOGRAPHY OF ESTROGENS ON NaOH-CELITE AND $NaHCO_3$-CELITE COLUMNS

Expt.	No. of trials	γ of estrogen chromatogrammed			Av. % recovery of estrogen in benzene fraction				
		Estrone	Estradiol	Estriol	I (30 ml)	II (80 ml)	III (10 ml)	IV (90 ml)	V* (100 ml)
A	7	10	0	0	0	99.7	—	—	—
B	6	0	10	0	0	0	0	99.4	—
C	3	0	0	10	0	0	0	0	99.9
D	1	10	10	0	0	90.5	0	102.0	—
E	1	5	5	0	0	113.0	0	103.0	—
F	5	2	2	0	0	104.0	0	95.5	—
G	2	5	5	5	0	97.1	0	95.5	99.8
H	6	2	2	2	0	93.4	0	91.6	102.1
			Mean			98.77		96.17	101.07
			Standard deviation			± 7.52		± 8.02	± 7.86
			Range			84.5–113.0		82.5–110.0	89.3–112.5

* Fraction V represents the eluent from the modified NaOH-Celite column.

Table 1 contains a summary of the results obtained when 2–10 γ amounts of estrone, estradiol, and estriol were chromatographed separately and together. It is apparent that the NaOH-Celite system is adequate for the separation of estrone from estradiol (Expts. A, B, D, E, F). The presence of a forerun and a distinct intermediate "clear" zone between the two estrogens should be a valuable aid in purification. Expt. C demonstrates that estriol is not eluted from the NaOH-Celite column by benzene. After modification to a $NaHCO_3$-Celite column with CO_2, the estriol is readily recovered in the benzene effluent. Expts. G and H illustrate the separation of 2 and 5 γ quantities of the three estrogens. The over-all accuracy appears satisfactory as judged by the means and standard deviations of the recovery of estrone, estradiol, and estriol.

The modified partition chromatography method described here quantitatively separates 2–10 γ amounts

[1] Estrone and β-estradiol were generously supplied by Edward Henderson, of the Schering Corporation.
[2] Estriol from Parke, Davis & Company.

of the three estrogens. The partition column is of small size and is simple, rapid, and uncomplicated in operation. The application of this method to the determination of the microquantities of estrogens present in blood is now in progress.

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Induced Emigrations Among Small Mammals

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This study of the effect of intensive trapping over a large area upon the members of the surrounding population consists of two experiments. One of them was conducted on Mount Desert Island, Me., during the summer of 1950; the second, in the Huntington Wildlife Forest near Newcombe, N. Y., during the summer and fall of 1951. The predominant genera of mammals inhabiting these forested areas are *Peromyscus, Clethrionomys, Blarina,* and *Sorex,* which may be considered as a biological unit designated as "small mammals."

The population was reduced by the rapid removal of individual animals from the study areas by operating groups of trap lines. Each trap line consisted of 20 stations 50 feet apart, with 3 traps at each station. The several trap lines in each location were distributed so that they formed a rough rectangle. In each case the distribution was such that the population resident on 40–80 acres was reduced nearly 60% during the first 3 days of trapping. On the Maine location, 8 trap lines were used, making a total of 480 traps set each night. The term "trap night" will be used to indicate one trap set one night. On the Maine location trapping was run for 15 consecutive days with a terminal 3-day period of trapping following a 5-day interval. On the New York location, four trap lines were set during the first 10 days. Two were placed in the form of a cross on each of the opposite corners of a quarter-section. From the 11th through the 33rd day, 5.3 trap lines within and at the other two corners of the quarter-section were added. Although this procedure increased the area of sampling,

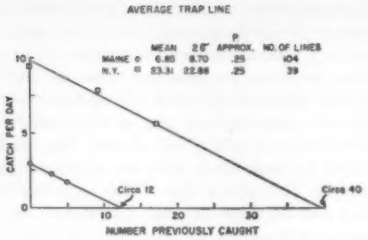

FIG. 1. Average trap lines for Maine and New York. Data for Maine cover 104 trap lines run during 1949, 1950, and 1951. Data for New York cover 39 trap lines run during 1951. Were the approximate probability of capture ($P = .25$) to continue on later days without invasion, the resident population exposed to an average trap line would be indicated by the intersection of the abscissa by the lines drawn through the first 3 days' captures.

it did not appear to alter the trend of the results.

The study on the Maine location was conducted by A. Dexter Hinekley under the supervision of John B. Calhoun. The study on the New York location was conducted by William L. Webb and Earl F. Patric.

In both locations large numbers of trap lines have been run at other sites within the same general habitat, and the resultant data (Fig. 1) reveal the general effect that this method of trapping has upon the resident population. The population at the Maine location was less than one third that in New York. The t test of the significance of the difference between the mean population densities of the two areas has a probability of less than .001. In both areas, the trend of decrease through the first 3 days was such as to indicate an approximate probability of capture of 0.25—i.e., on the initial day 25% of the population is removed, and on each succeeding day 25% of those remaining is removed. Were there no invasion

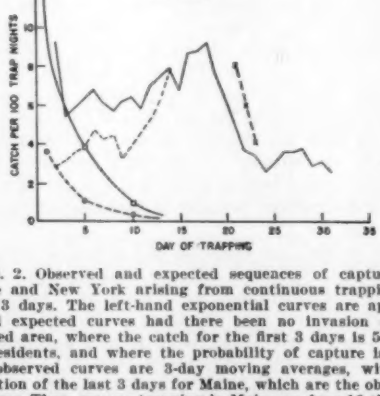

FIG. 2. Observed and expected sequences of captures in Maine and New York arising from continuous trapping beyond 3 days. The left-hand exponential curves are approximated expected curves had there been no invasion of the trapped area, where the catch for the first 3 days is 58% of the residents, and where the probability of capture is 0.25. The observed curves are 3-day moving averages, with the exception of the last 3 days for Maine, which are the observed captures. There was no trapping in Maine on days 16 through 20. The 425 animals taken in Maine and the 855 taken in New York are shown in terms of catch per 100 trap nights for the sake of a better comparison.

from surrounding areas, the resident population would be essentially removed at the end of 10 days. Data showing similar results to those of Fig. 1 are available for approximately 1000 of these standardized trap lines (*1*).

In contrast with the hypothetical trends in the removal of resident populations, shown in the two left-hand exponential curves in Fig. 2, the observed trends show that there was a marked invasion accompanying the continuous trapping in each of the two locations. The number of invaders in Maine during the first 23 days was five times that of the calculated original resident population. Similarly, on the New York location the number of invaders during the period of 23 days was 2.3 times the calculated resident population. It will be noted that in the New York location, which had the higher relative density, the rate of invasion was lower than in Maine. In both places invasion appears to have stopped sometime after the 16th–18th day. In New York there was a period of 6 days in which the captures seem to have been merely a removal of those animals that had arrived by the 18th day. Later there was a slight secondary invasion.

Several concepts may provide the basis for a tentative hypothesis to explain this invasion. The first point of consideration is the extent of the area depleted by continuous trapping. In each case the minimum distance across the trapping area slightly exceeded 1000 feet. We assume that this distance is sufficient to insure that untrapped animals living to one side of the trapping area are unable to detect the presence of other untrapped individuals on the opposite side. In other words, there was produced through the initial 3 days of trapping a "biological vacuum" insofar as the frequency and intensity of perception of neighbors were concerned.

Since small mammals move into the denuded area so rapidly, it is suspected that shifting the place of habitation is a response directly related to the relative intensity, frequency, or both, of perceiving neighbors at a distance. There are at least two alternative hypotheses to explain movement into the biological vacuum. First, as each animal moves about its home range, it must from time to time perceive its neighbors. If an avoidance response were to result from these perceptions, each individual would tend to concentrate its activities at some distance from any neighbors. In the case of the artificially produced biological vacuum, the center of activity of those individuals living on the periphery will shift away from the higher concentration of neighbors and toward the depleted area. Second, each individual may become conditioned to a certain pattern of perception of neighbors about its home range. This pattern may be one of unequal intensity, or unequal frequency of perception in various directions. This is an anticipated situation where irregularities in the physical environment affect density of distribution. Where there is an alteration in the pattern in any direction, the animal affected will shift its home range in such a way that the pattern or ratio of frequency of perceiving its neighbors will remain the same, although the absolute level of intensity of the stimuli in question may be altered. Thus, when a biological vacuum suddenly appears at one side of an animal's home range, it will move in the direction of this depleted area as if in an attempt to encounter again the stimuli produced by neighbors. It may well be that both intensity and pattern alterations in perception are simultaneously involved.

Whatever the exact mechanism underlying the response, those animals living just peripheral to the area subject to continuous trapping do move into it. As soon as the shift occurs, the next group living still farther away must move into the area just vacated by the previous group. Through this process a biological chain response is established whereby a simultaneous movement toward the central depleted area extends for a considerable distance away from the periphery of the trapping area.

If the inward movement covers a constant distance per day, one would expect that the number of invaders captured in the central area would increase daily, because consecutive bands of equivalent width (w) but lying at even greater distances from the periphery of the depleted locality increase in area at a constant rate of $2\pi w^2$. Thus, where density is proportional to area, an increasing catch per day might be anticipated. These generalizations are based upon the hypothetical use of a circular depleted area.

A trend toward an increasing catch on successive days is evident in the data from both locations (Fig. 2). At least this applies from the third day approximately through the 15th–18th. The fluctuations in the trend may well be dependent upon fluctuations in density through the habitat, as well as upon the effect of variations in the weather on the movement of the animals with reference to the traps.

Fig. 2 shows that the increase in catch per day was greater in Maine than in New York. Just the reverse might have been anticipated upon the basis of the greater density in New York, had all other factors affecting the invasion been the same. Our present data are inadequate to offer any explanation for the possible existence of an inverse relationship between density and rate of invasion. The causes of difference in rate of invasion most probably must be sought among factors that alter the distance (w) moved per day during invasion, or that affect the proportion of the population set in motion.

Many other studies (*2, 3*) have reported data concerning the capture of small mammals from a central area exposed to continuous trapping. These studies differ from ours in that the diameters of the areas were much more limited, ranging in general from 1 to 10 acres. In the case of smaller tracts there is only a gradual drifting in of nonresidents, in contrast to the more marked invasion observed in the present studies. The absence of any marked invasion, we believe, is attributable to the ability of the animals to

detect others across the smaller depleted area. We have under way several more extensive and refined experiments designed to elucidate the above hypotheses, as well as to provide data on some variables not discussed here.

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Heterotransplantation of Human Tumors Into Cortisone-treated Rats

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Ever since the experiments of Murphy, starting in 1914 (*1*), the role of the lymphocytes of the host in the resistance to heterotransplantation has been the subject for intensive investigations. The production of antibodies by lymphocytes has been established (*2*), and the release of immune γ-globulin from lymphocytes demonstrated (*3, 4*). Murphy observed the persistence of transplanted mice tumors in x-irradiated rats (*5*). Recently it has been shown (*6*) that large doses of x-ray to rats and mice make these animals receptive to heterotransplantation of human tumors, and successive transplantations were carried out. The success of this experiment, as of those of Murphy, was related to the reduced lymphocyte counts of the irradiated animals. Prior to this experiment, transplantation of human tumors was successful only when it was carried out in the anterior chamber of the rabbit eye (*7, 8*).

As the administration of cortisone results in a greatly reduced lymphocyte count, heterotransplantation of human tumors in cortisone-treated rats was attempted. It was found previously by Foley and Silverstein (*9*) and by Howes (*10*) that the strain-specific resistance to transplantation of tumors in mice is greatly impaired by treatment with cortisone.

Biopsy material of human tumors was transplanted. Generally no more than 10–15 min elapsed between the removal of the tumor, establishing of the diagnosis by frozen section, and transplantation of the tissue into cortisone-treated rats. The tumor was cut into small fragments and transplanted, by the use of a trochar (1–2 mm diam), subcutaneously into the left inguinal region of 3 or 4 treated rats. The pretreatment of the rats varied because of the irregularity of the receipt of suitable material from the operating theatre. As rats had to be kept prepared, the number of injections before the transplantation varied between one and four. Young Wistar rats, mostly females, at the age of 4–6 weeks, were used. The rats received 25 or 12.5 mg of aqueous suspension of cortisone acetate subcutaneously at 2- or 3-day intervals. No untoward effects were manifest in the rats except for retardation in growth. Nine tumors were transplanted. Table 1 shows the origin of tumors transplanted and the results. Photomicrograms of tumors are given in Figs. 1 and 2. Rats were killed 4–21 days after transplantation, but as a rule after 8 days. The skin and muscle around the transplant were examined, and any nodules found were studied histologically. With the exception of one rat, killed 4 days after transplantation, no inflammatory reaction was found around the transplant. The survival of the transplanted tissue was judged by the size of the transplant, by the healthy occurrence of the tumor cells, and by the presence of mitoses in the sections. Reliable evidence for growth are the mitoses found several days after transplantation. The size of the transplants increased during the days following transplantation and was 4–5 times that of the original size after 10–14 days. The increase in size alone, however, cannot be taken as a measure of the growth of a transplant, since fibroblastic proliferation of the host tissues may also participate. No serial transplantation was attempted. Out of 9 tumors transplanted into 28 rats, positive results were obtained with 8 tumors in 14 rats. A carcinoma of the kidney was the only tumor not transplantable to any of the rats. This tumor was heavily infected. None of the tumors grew in all rats to which they were transplanted; the highest take was 3 out of

TABLE 1

Tumor transplanted	No. of rats	No. injections before transplantation	No. injections after transplantation	No. of successful transplants
Cancer of bronchus	4	2	3	1(4)* 1(12) 1(16)
Cancer of breast	3	4	2	1(8)
Metastasized lymphnode cancer of bronchus	3	2	2	2(13)
Cancer of breast	3	3	3	1(10)
Juvenile melanoma	3	4	3	2(8)
Cancer of breast	3	1	4	1(12)
Cancer of esophagus	3	3	3	2(8)
Cancer of kidney	3	2	3	0(7)
Ependymoblastoma	3	3	3	2(12)

* Figures in parenthesis represent the days after transplantation at which the rats were killed.

4 rats. The tumors seemed to regress 19–20 days after transplantation. A transplant of a bronchogenic carcinoma investigated 21 days after transplantation showed marked fibrosis and only a few degenerating tumor cells. Also, no inflammatory reaction was seen around this transplant. Two other transplants of the same tumor were found persistent in rats killed 8 days after the transplantation. Transplants into one group of rats not treated with cortisone was unsuccessful.

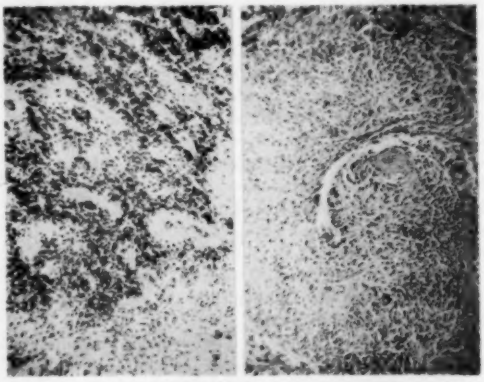

FIG. 1. Ependymoblastoma: Left, original tumor, ×70; right, transplant 12 days old. Note mitosis.

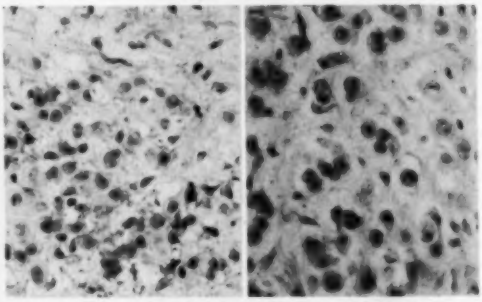

FIG. 2. Bronchogenic carcinoma: Left, original tumor, ×300; right, transplant 12 days old. Note mitosis.

In two rats with successful grafts, blood counts of the heart blood were made at the time each animal was sacrificed. The total blood count in one rat was 1900 leucocytes, with 10% lymphocytes; in the other, the count was 1900 leucocytes and 7% lymphocytes. The number of leucocytes in normal rats is 12–15,000, with 65–75% lymphocytes. The red blood cell count was about normal.

Other changes found in cortisone-treated rats were the reduction in the size of adrenals, spleen, and thymus. In the spleen a very marked increase of the giant cells was observed. An increase in the number of splenic giant cells after transplantation of chemically induced tumors in mice was studied by Parsons *et al.* (*11, 12*). In 4 rats, killed 9–14 days after transplantation, marked dilatation of the pelvis of the kidney was found, and in the histological preparation a corresponding dilatation of the collecting tubules was observed. In all rats, a marked development of the mammary tissue was found. The ovaries contained ripening follicles, but no corpora lutea.

It is as yet impossible to state whether the survival of human tissue transplants in rats is directly connected with the disappearance of lymphocytes of the circulation or whether a disturbance occurs in the whole cellular metabolism of the cortisone-treated animals. It was not attempted to establish in which percentage of all tumors heterotransplantation might be successful, or which kind of tumors are more suitable for transplantation. The aim of this study was to show that cortisone changes the inner environment of an animal in such a way that its resistance to heterotransplantation is greatly diminished.

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Conformity to Social Norms in Stable and Temporary Groups[1]

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When members of small face-to-face groups, whose structure had facilitated verbal interaction, were confronted with a green rectangle and asked to estimate its length anonymously, the dispersion of their perceptual judgments was significantly greater than the dispersion of estimates from groups whose structure had tended to inhibit such interaction (*1*). Further, when the individual estimates and their average or norm were presented to each group, respectively, and members were asked to re-estimate the length of the rectangle anonymously, a significantly greater reduction in dispersion of estimates compared to the initial

[1] This work was undertaken in the summer of 1949 as part of the Conference Research Project at the University of Michigan, sponsored by the Office of Naval Research (Contract N60nr-232, T.O. 70), under the general direction of Donald G. Marquis, chairman of the Department of Psychology.

[2] The writer is indebted to Dr. Marquis for the original suggestion which led to this study, and to Harold Guetzkow, project coordinator, for further advice and assistance.

dispersion was obtained in those groups with more experience of interaction (*1*).

These results suggest that modification of individual perceptions of an objective stimulus in the direction of a group norm is a function of group structure, more particularly of the amount of verbal interaction among group members facilitated by such structure. To further explore this latter proposition, two small group populations representing extremes in interaction experienced were selected for experimentation at the University of Michigan.

The first of these populations was made up of six so-called stable groups, ranging in size from 6 to 14 persons, who had met together voluntarily in their respective groups for an average of 231 hr and were extremely likely to continue meeting together. These groups totaled 55 persons. Included in this population were a group of teaching fellows from one of the university departments, tested while attending a dance together; a group of girls living in one of the university's international houses, tested while attending the same dance; a Quaker organization; a church baseball team; a graduate outing club; and a Fundamentalist group.

The second of the populations was made up of seven so-called temporary groups, ranging in size from 6 to 11 members, who had met together for an average of 2.47 hr and were not likely to continue meeting voluntarily. There was a total of 53 persons in these groups. One of the groups consisted of volunteers from an elementary psychology class who had known each other for an average of 14 hr and who, according to their instructor, were not likely to meet again in the absence of external compulsion. The other six groups in this population were made up of individuals arbitrarily selected by the experimenter as they walked across the campus and asked if they would like to participate in a brief experiment in social psychology. None of these persons had met before. The average existence of the six groups was about 20 min.

In the first experiment conducted with these two populations, each subject was asked to estimate the number of dots in a square enclosing 500 dots that had been presented to him, within a time limit of approximately 30 sec. Following this initial estimate, the group was informed of the individual estimates by its members (but not who had made each one) and their average or norm, as computed by the experimenter. A second anonymous estimate, within the same time limit, was then requested of the group members.

Results indicated a significantly greater dispersion of initial estimates of the number of dots from the stable groups. The standard deviation of estimates from this population of small groups was 889, compared to 386 for the temporary groups. This difference yielded a critical ratio of 5.56, and hence the probability that it could have occurred by chance is less than .0000006.

The results also indicated a significantly greater reduction in dispersion from first to second estimates for the stable groups, compared to the temporary groups. Following presentation of the individual estimates and their average, the standard deviation of the stable group estimates was reduced by 440 units, whereas the standard deviation of the temporary groups was reduced by 58 units. This difference in shrinkage of the original dispersions yielded a critical ratio of 4.88, indicating that the probability it could have happened by chance is less than .000002. The statistical formula used here was developed by McNemar (*2*).

When initial dispersions of the stable and temporary groups were mathematically equated by expressing the absolute change in standard deviation for each population as a proportion of the initial standard deviation for that population, greater relative shrinkage or convergence of estimates was still obtained for the stable group population. Percentage of change with respect to the initial standard deviation of estimates was 49 for the stable groups and 15 for the temporary groups. It should be noted that in the case of every group tested the standard deviation of the second estimates was smaller than the standard deviation of the initial estimates.

When, however, in a second experiment immediately following the first, the same experimental procedure was repeated for each group, using as a stimulus a green rectangle the length of which was to be judged, no statistically meaningful differences of any sort were found in regard to initial dispersion or shrinkage of such dispersion following presentation of the group norm, between stable and temporary group populations. This finding is in direct contrast to results of a previous experiment with the green rectangle, mentioned above (*1*). It is possible that the negative result found in this instance was due to the fact that the experiment with the green rectangle directly followed the experiment with the dots, and hence by analogy the subjects were able to guess in advance what the experimental procedure would be, as suggested by Guetzkow (*3*). Another experimental study had indicated that the obtained phenomena of differences in initial divergence of estimates and in convergence following presentation of the group norm, between groups who had and who had not had extensive experience of verbal interaction, did not obtain when subjects were sophisticated in regard to the experimental procedure (*1*).

Whatever the mechanism by means of which the group influences the perceptions of its members, even their perceptions of objective stimuli, it should be noted that the individual is not always aware of its operation. In the case of the first experiment with the green rectangle (*1*), some individuals reported seeing the rectangle as smaller or larger the second time they had to judge its length. Anonymous reports from one group, whose members were asked to explain why they had changed their estimates from the

first to second judgment situations, included "It looked larger," "It appeared smaller," "It appeared larger the second time," and "It was held slightly closer to me." None of these conditions was, of course, objectively true.

An adequate theoretical explanation would have to take into account not only the above phenomenon, but also the means by which the group situation, *before* individual estimates and their average had been presented to members, had operated to yield a substantially smaller initial dispersion of estimates in those groups with little experience of interaction among their members.

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Comments and Communications

Phosphorylated Hesperidin

In an article published in Science (**115**, 402 [1952]) we reported preliminary results indicating the production of an antifertility effect in rats by the oral administration of phosphorylated hesperidin. Experiments designed to check these findings, in which mice, as well as larger numbers of rats have been used, have given inconsistent results. Negative results have been obtained with samples of material synthesized at different times and under slightly different conditions from that originally reported on.

Phosphorylated hesperidin as first prepared (*1*) was known to be a mixture. Subsequent chromatographic work (*2*) has shown the presence of several different components; the number of these and their identity (as determined by the position of the spots) will vary with slight changes in the method of synthesis of the sample being examined. Finally, it has been found (*3, 4*) that changes in the method of synthesis that will not affect the degree of phosphorylation will affect the antihyaluronidase effect of the substance *in vivo* and *in vitro*.

It would appear, then, that the antifertility effect of phosphorylated hesperidin is a function of one component of a mixture of different phosphates. Work on the isolation and identification of this substance is now in progress.

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A Type of Large-Volume Vacuum Ampul

Large-volume ampuls, as containers of dextrose solution or normal saline injections, are still commonly used in the Far East. They are better than bottles from the standpoint of air leakage, as has been observed among some carelessly stored goods in Taiwan. They are simple and cheap in comparison with bottles of other types. Because of the weakness of glass, ordinary ampuls cannot withstand pressure, and break easily during sterilization. Actually, in the empty space of an ampul during sterilization at 100° C the partial pressure of air is $1 \times \frac{337}{293}$ atmospheric pressure

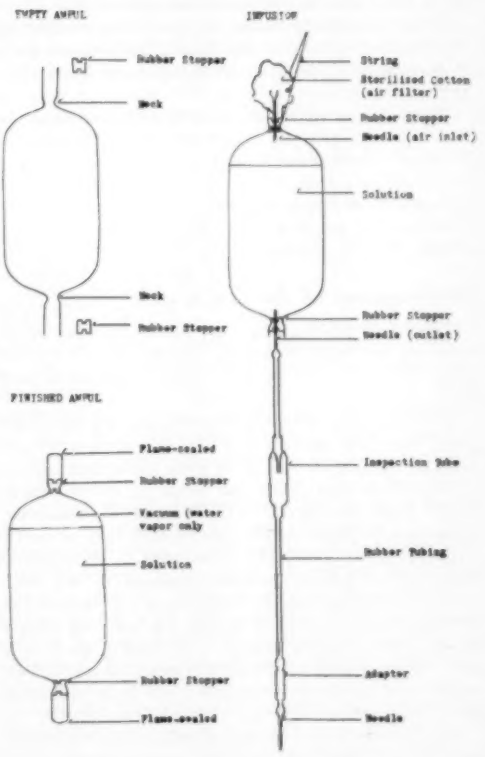

Fig. 1.

absolute and that of water vapor is 1 atmosphere, making a total pressure of about 2.3. At 120° C, or under 15 psi, the total pressure is about 3.3. Hence, in order to avoid breakage, the diameter of the ampul must be made in accordance with the formula $D \times P = 2\ t \times s$, where D = diameter of the ampul, P = total pressure inside, t = thickness of the wall, and s = tensile strength of the glass.

The lower the pressure, the more stable will the ampul be. On this principle a vacuum ampul is suggested as in Fig. 1.

The two ends of the ampul are left open for convenient cleaning. A rubber stopper is inserted into one of the necks before filling; the other is also stoppered after filling, but this rubber stopper is penetrated with a needle to evacuate the empty space. The two ends are then flame-sealed. Such ampuls will not break when autoclaved under steam pressure.

Before use, the two ends are sawed between the rubber stoppers and the sealed points. In doing so, there is no danger of glass powder or splinters falling into the solution.

These large-volume vacuum ampuls can also be satisfactorily used as containers for anticoagulant for whole blood transfusion.

CHEN LU-AO

Pyrogen Free Fluids Plant
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Investigation of the Coelacanth

IT was my privilege to carry out detailed investigations on the first Coelacanth, and to have discovered what appears to be the area where those fishes still live.

The recent Comoran Coelacanth, although mutilated more than was at first realized, nevertheless retains most of the soft parts, including the abdominal viscera. This extends enormously the scope of the investigational work that may be carried out on the specimen. There will be still more that can be done only on parts, exudates, and secretions from an untreated fresh specimen, which it is hoped may be sought before very long.

It is in keeping with the importance and scope of the investigations on all parts of this fish that they should be assigned to leading experts in the field in which they fall. I have advised the South African Council for Scientific and Industrial Research, and have requested their approval of, and cooperation in, this matter.

Application to be included in this scheme should be sent either to the South African Council for Scientific and Industrial Research, P. O. Box 395, Pretoria, or to me personally at Rhodes University, Grahamstown. Every possible facility will be granted to selected visiting specialists, but it should be noted that there is no possibility of financial aid from this end.

The ownership of the next specimen or specimens is of less importance than proper preservation for scientific purposes.

As certain organs and body fluids require special treatment and preservation, it is intended to compile a set of special instructions to be issued to those in areas where it is likely that a fresh Coelacanth may be obtained. It will be appreciated if those interested will kindly furnish detailed special instructions composed in language as simple as possible, giving full directions and not only the names, but also the actual composition, of any materials to be employed.

Since there is a hope that more Coelacanths may be found at the Comoro Islands, it is desirable that all such materials should be available there.

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Classification of Variable Material

SOMEWHERE we need to have exact and detailed descriptions of what nature offers us, even in the most variable material. The practice of assembling as many as possible of the phenotypes into as few as possible varieties and forms is necessary in manuals, but more detailed description should be available. For some years we have found it profitable to follow the example of the geneticists and designate by letters the different conditions that we find. For example, the common moss *Leptodictyum riparium* varies in shape of apex of leaf, in length of midrib, and in width of cells. If we represent the typical form by *ABC*, and the contrasting characters by *abc*, we actually find in nature ABC, ABc, AbC, Abc, aBc, abc. The last two have received Latin names. If we list all of these arbitrarily under one or other of the three available Latin names, we will obscure the facts as to what actually occurs. If we give three more Latin names, we will be complicating the synonymy, to no avail. And if one or more additional characters are considered, a greater number of combinations will be found.

Instead of multiplying Latin names as Greene did for *Ptelea*, and Podpera for *Bryum capillare*, I recommend the briefer and more exact description by means of combinations of code letters. The code must be adapted for each species described. It should not be concluded that the letters represent genes. When the genetics of the species have been worked out, the genetical formulas should supplant these phenotypic terms. Numerous species of mosses need this type of description. The same may be said for many flowering plants, and for many insects, birds, and mammals. This system is preferable to the endless multiplication of Latin names with Latin descriptions, to be cited ever after with the names of one or two authorities. A paper in preparation will give a detailed illustration of this method.

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Book Reviews

Die Mathematischen Hilfsmittel des Physikers. 4th ed. Vol. IV of *Die Grundlehren der Mathematischen Wissenschaften in Einzeldarstellungen.* Erwin Madelung. W. Berlin: Springer-Verlag, 1950. 531 pp. Illus. $11.88.

Madelung's book has been considerably enlarged and in many parts completely rewritten in its fourth edition.

This work is not a textbook, neither is it a collection of formulas. Originating from the author's collection of mathematical notes to his lectures in theoretical physics, it was intended to be for the theoretical physicist what Kohlrausch's *Practical Physics* is for the experimentalist. This goal has not been attained. Kohlrausch's book is a text of experimental physics in terms of definite problems and their solution, whereas Madelung's is a compendium of mathematics (350 pp.), followed by a brief summary of theoretical physics (143 pp.) arranged in the conventional sequence of textbooks. Thus, the mathematical tools are developed and discussed in some detail without reference to the physical applications (see, for example, the introduction to spin matrices, p. 25, and Clifford's numbers, pp. 12 and 25). Special developments are included in an appendix of about 30 pages.

The sequence follows the outline of the third edition, which was reprinted by Dover during the war. A first chapter on numbers, functions, and operators is entirely new and has been added in view of the widespread use of operators by physicists in recent years. In this chapter some of the tools of quantum mechanical calculations are formally introduced.

A brief chapter on differential and integral calculus is followed by series and series developments, a chapter on functions (including some 50 pages on special functions), and a chapter on algebraic transformation. The detailed and well-developed chapter on vector analysis will be welcome to students and teachers. This is followed by discussions of special coordinate systems, group theory, differential equations, integral equations, calculus of variations, and statistics. Under group theory, a discussion of the crystallographic symmetry groups as used in structure analysis has been added. The chapter on theory of differential equations is written from the point of view of wave mechanics and modern physics.

The discussion of general relativity theory has been cut considerably—the Einstein effects formerly discussed in an appendix are now mentioned in three lines. This was inevitable, however, if the new mathematical techniques, modern developments in quantum mechanics, and the approach to problems of field theory were to be discussed.

Physics is discussed in separate chapters on mechanics, electrodynamics, relativity, quantum theory, thermodynamics, and statistical methods. Crystal optics, as part of electrodynamics, is particularly well summarized, and the same thing is true of the discussion of thermodynamics. However, some of the more modern applications would be welcome, particularly statistical applications to the theory of the solid state.

The literature contains only a few new references, published since the third edition came out. The index, quite important in a book of this type, has been cut to five and one-half pages for the 500 pages of text—whereas the index in the third edition was more than ten pages, covering a text of some 350 pages. The index is now so brief that it is not quite clear what will be found under a particular heading. For example, "Approximation methods" are quite important for the use of such a book; in the former edition there were five entries describing in detail the approximation referred to. At the present time there is just one entry.

This reviewer hopes that, if another edition comes out, particular care will be taken to make the index so complete that it will be simple for a physicist to find the material he needs for the understanding of theoretical developments in his own field.

KARL LARK-HOROVITZ
Department of Physics, Purdue University

Survey of Biological Progress, Vol. II. George S. Avery, Jr., Ed. New York: Academic Press, 1952. 333 pp. Illus. $7.00.

This thin volume is the latest of a series begun in 1949. It covers a broad field of biology—ranging from genetics to physical chemistry and from anatomy to plant pharmacology. By and large it is a moderately interesting volume and one in which most biologists will find at least one article they can read with profit.

The first paper, "The Effects of Radiation on Biological Systems," by A. H. Sparrow and B. A. Rubin, is a most useful, concise presentation of modern thoughts on the inorganic and physical chemistry, physics, and biology of radiobiology. It includes a detailed discussion of the target theory and its interpretation in modern chemical terms. Here also is a precise summary of our knowledge of the ions and radicals formed by the varied kinds of high-energy radiations. Finally, the varied biological effects of radiation are treated with respect to mutation and cytology and physiology. Similarities and differences of the effects of high-energy radiations are outlined in an admirable way. This is an outstanding article—one that might well be read by all biologists not themselves specialists in the field.

"Progress in Human Genetics," by H. Kalmus summarizes the little we know about human genetics. Kalmus brings together, in rather general terms, much about the inheritance of human traits as well as modern information on mutation rates, and interesting calculations about the size of mating groups in the human community.

Gordon Riley's "Biological Oceanography" flows along in an admirable way and is a pleasure to read. Dr. Riley's emphasis is on ecological matters, and some might wish that he could bring a little more specific information to bear on the intricate problems of life in the ocean.

Erwin Bünning, who has written extensively in German on morphogenesis and related matters in higher plants, has prepared an English summary of his views for this volume. Bünning is a hard master, and the reader must follow his involved arguments with care if he is to follow them at all. This author does, however, present extraordinarily lucid and specific chemical interpretations of the forces that control and guide the course of morphogenesis. To Bünning, we have in higher plants clear evidence of induction of differentiation by specific substances. An important part of his discussion is that concerned with his principle of mutual incompatibility of regions of vigorous protoplasmic growth—a principle which again finds its basis in Bünning's mind in competition for specific chemical substances. He also takes care to differentiate between regulators, which bring about cellular activity in general, and determiners, which channel differentiation along particular pathways. It is high time that a clear distinction of this kind be made in the discussion of plant morphogenesis.

The review by L. G. Nickell concerns the rapidly developing field of the chemical regulators of plant growth. He considers the auxins and related compounds in weed control and in other agricultural problems and deals briefly with certain auxiliary matters such as the toxicity of these compounds to animals. The whole discussion is on a descriptive basis, however, and does not attempt to synthesize the thoughts of various workers concerning why these compounds act the way they do; nor does he consider the systematization of our knowledge of chemical structure and biological activity in these compounds.

Histochemistry is now undergoing rapid development along two rather distinct lines. Florence Moog adheres to the school of thought which proposes to study the cellular localization of enzymatic reactions in tissue slices as followed under the microscope. Her paper stresses this approach rather than the approach of physical separation of cellular constituents, which has proved so fruitful. To the reviewer it would seem that Moog's discussion merely establishes again that the classical methods of histochemistry are less sure in application to the living cell than are those of differential centrifugation.

Cell structure also plays an important role in L. H. Bretschneider's review, "The Fine Structure of Protoplasm." Bretschneider presents a cogent and closely reasoned argument for the supposition that protoplasm does indeed possess a structure of submicroscopic strands, each with a diameter of roughly 50–200 A. These fibrillar structures can be seen in electron micrographs of many types of dehydrated cytoplasm. To the reviewer it is still open to question whether these same units, designated by Bretschneider as "leptons," are in fact to be found in the native hydrated cytoplasm.

The final contribution, by Aubrey W. Naylor, "Physiology of Reproduction in Plants," includes not only a summary of past work in the reproduction of fungi and algae, but also a considerable discussion of reproduction of higher plants.

If one general criticism might be leveled at the present volume, it would be that several of the papers are diffuse, general, and overly talkative. They lack the initial clear delineation of the problem and the concise treatment that have become characteristic of reviews in chemistry and biochemistry. The subjects presented here are important and interesting ones. They deserve treatment in a precise, brief manner, and with clear terminology.

JAMES BONNER

Division of Biology
California Institute of Technology

Scientific Book Register

Elsevier's Encyclopaedia of Organic Chemistry. Series III: ***Carboisocyclic Condensed Compounds,*** Vol. 14, Suppl. 2: ***Triterpenes.*** F. Radt, Ed.; Dora Stern, Co-editor. Amsterdam-Houston: Elsevier, 1952. 407 pp. + 50 pp. index. $40.00; set subscription price, $30.00.

The Trichoptera (Caddis-Flies) of Australia and New Zealand. Described and figured by Martin E. Mosely and D. E. Kimmins. London: British Museum (Natural History), 1953. 550 pp. Illus. £4 10s.

Ciba Foundation Colloquia on Endocrinology. Vol. I, ***Steroid Hormones and Tumour Growth and Steroid Hormones and Enzymes;*** Vol. II, ***Steroid Metabolism and Estimation.*** G. E. W. Wolstenholme, Gen. Ed.; Margaret P. Cameron, Asst. New York: Blakiston; London: J. & A. Churchill, 1952. Vol. I: 315 pp. + plates; Vol. II: 429 pp. Illus.

The Principles of Line Illustration. With emphasis on the requirements of biological and other scientific workers. L. N. Staniland. Cambridge, Mass.: Harvard Univ. Press, 1953. 212 pp. Illus. $5.00.

Organic Chemistry. Melvin J. Astle and J. Reid Shelton. New York: Harper, 1953. 771 pp. Illus. $7.50.

What Is Science? Repr. Norman Campbell. New York: Dover, 1952. 186 pp. $2.50; paperbound, $1.25.

The New Force: The Story of Atoms and People. Ralph E. Lapp. New York: Harper, 1953. 238 pp. $3.00.

Statistical Theory in Research, Part I: ***Basic Statistical Theory;*** Part II: ***Analysis of Experimental Models by Least Squares.*** R. L. Anderson and T. A. Bancroft. New York–London: McGraw-Hill, 1952. 399 pp. $7.00.

Dating the Past: An Introduction to Geochronology. 3rd ed. Frederick E. Zeuner. London: Methuen; New York: Longmans, Green, 1952. 495 pp., illus., and 24 plates. $8.00.

Lectures on Cauchy's Problem in Linear Partial Differential Equations. Repr. Jacques Hadamard. New York: Dover, 1952. 316 pp. Illus. $3.50; paperbound $1.70.

Advanced Statistical Methods in Biometric Research. C. Radhakrishna Rao. New York: Wiley; London: Chapman & Hall, 1952. 390 pp. $7.50.

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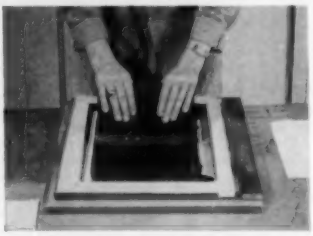

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An Introduction to Linear Programming. A. Charnes, W. W. Cooper, and A. Henderson. New York: Wiley; London: Chapman & Hall, 1953. 74 pp. Illus. $2.50.

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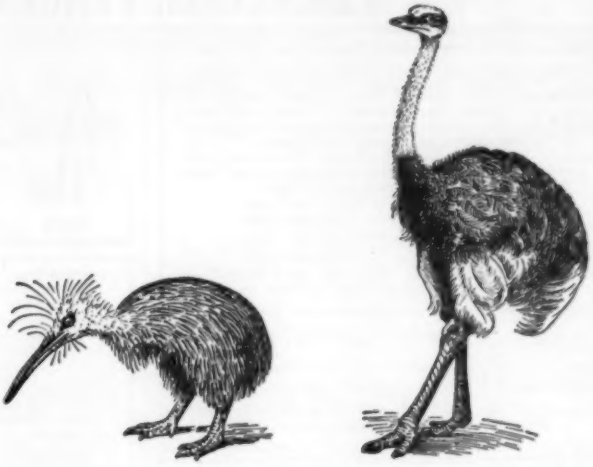

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C. W. LaPIERRE

Mr. LaPierre is a Company vice president and is general manager of the Aircraft Gas Turbine Division

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I. F. KINNARD

Mr. Kinnard, with GE since 1922, is manager of the Engineering, Meter, and Instrument Department.

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General Electric Review

J. E. BURKE

Dr. Burke is manager of the Metallurgy Section of the Knolls Atomic Power Laboratory

". . . Since vanadium appeared to be a possible material for use in nuclear reactors, a program to investigate its properties was undertaken several years ago. Although nominally pure vanadium had been available for a number of years, it was brittle and could not be fabricated. Some ductile vanadium had been prepared by calcium reduction of the oxide, but only beads and small pellets were produced. In improving this product, additions of iodine were made to the mixture of V_2O_5 and calcium. Upon heating this charge in a closed pressure vessel, the additional heat provided by the combination of iodine and calcium raised the temperature enough so that a large ductile button of vanadium was obtained. Unfortunately, subsequent runs yielded buttons that were brittle. After extensive investigation it was finally found that the brittleness was due to nitride in the oxide, and the final procedure used involved a careful denitriding of the vanadium oxide by heating in moist oxygen for several hours. The product as now produced can be rolled into thin foil, drawn to wire, or given any of the standard metallurgical treatments except hot working. Because it avidly absorbs oxygen to become brittle, it can not be heated in air.

As in other fields, improvements in materials are imperative if important advances in reactors are to be made. These require continuing work not only directly in the development of better materials but also on the fundamental studies that pave the way for the applied developments.

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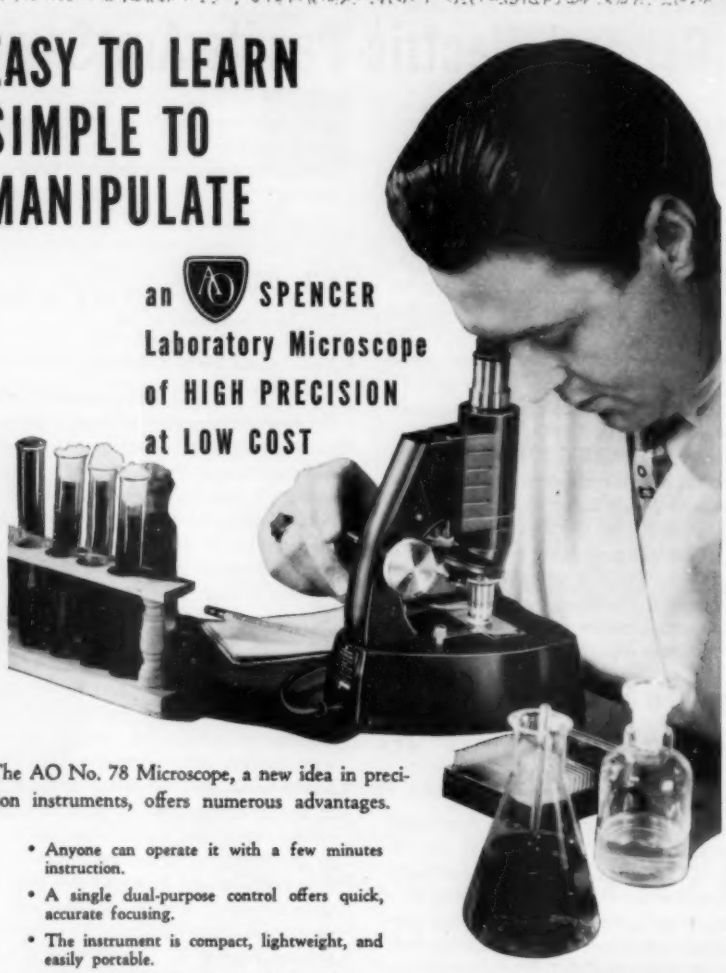

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